Chapter Eight

Habitat Enhancement and Restoration Guidelines

This chapter summarizes potential restoration, enhancement, and weeding programs for native habitats on Carmel Mountain and Del Mar Mesa. It should be noted that any privately owned lands within Carmel Mountain and Del Mar Mesa are not included within the Preserves until such time as the land is conserved in perpetuity by the landowner or acquired by a public or non-profit agency for the purposes of conservation. Any restoration or other activities depicted in this plan will not be implemented until the land is conserved or written permission is obtained from the landowner. Restoration of sensitive resources in the SDG&E access roads would only be done if these roads are no longer needed by SDG&E or for private landowner access to inholdings.

The short-leaved dudleya is a focal species for conservation on Carmel Mountain and along with the vernal pools and southern maritime chaparral habitats and the associated sensitive species is the reason that Carmel Mountain was conserved. The protection of sensitive vernal pool resources on Del Mar Mesa is the primary reason that lands have been conserved in that area. Carmel Mountain and Del Mar Mesa have unique geological and hydrological characteristics that have led to the development of equally unique biological features.

Therefore, this chapter provides additional detailed recommendations for the restoration, enhancement, and management of short-leaved dudleya and vernal pool habitats on Carmel Mountain and Del Mar Mesa. These recommendations are intended to ensure that the protection and management goals for these sensitive resources can be achieved.

In addition to the restoration, recommendation areas that would benefit from an active weeding program are also identified. Restoration and weeding will only be done as funding becomes available. It is recommended that weeding programs be given the highest priority for funding because an effectively implemented weeding program will improve habitat quality for the greatest number of species including both plants and animals. Short of direct impacts caused by human disturbance, weed invasion is considered the greatest threat to the sensitive species and habitats present in the Preserves.

Depending on which Reserve management structure option is chosen (see Chapter 4), the responsibility of habitat management and restoration will vary. If a habitat management committee is organized each landowning agency would be responsible for funding and implementation on their own properties. If an MOA is developed then one landowner would be assigned management responsibility of the Reserve. The selected agency would then be responsible for acting as the Habitat Manager under a cooperative agreement by the different landowners.

Habitat management actions would then be implemented preserve wide.

A. Short-leaved Dudleya

1. Short-leaved Dudleya Biology

The short-leaved dudleya populations on Carmel Mountain are being censused annually as part of MSCP rare plant monitoring program conducted by the City of San Diego (City of San Diego 2001). See Chapter 3 for conservation status of the short-leaved dudleya.

Typically, the short-leaved dudleya occupies openings within the maritime chaparral community that are dominated by cryptogamic crust species such as lichens, mosses, and ashy spike-moss. Herbaceous plants such as Cleveland's shooting stars (*Dodecatheon clevelandii*), dot-seed plantain (*Plantago erecta*), pygmy weed (*Crassula connata*), skunkweed (*Navarettia hamata*), spineflower (*Chorizanthe* sp.), herba impia (*Filago* sp.), popcorn flower (*Plagiobothrys* sp.), and everlasting nest straw (*Stylocline gnaphaliodes*) are also common associates.

Photograph 8-1: Short-leaved Dudleya Habitat (Subpopulation 3)

Photograph 8-2: Short-leaved Dudleya Habitat (close-up) on the Edge of the Mesa at Carmel Mountain

The southern maritime chaparral community that surrounds the short-leaved dudleya populations on Carmel Mountain include chamise (*Adenostoma fasciculatum*), mission mazanita (*Xylococcus bicolor*), black sage (*Salvia mellifera*), wart-stemmed ceanothus (*Ceanothus verrucosus*), and occasional Del Mar manzanita (*Arctostaphylos glandulosa* ssp. *crassifolia*). Like other members of the subgenus *Hasseanthus*, short-leaved dudleya is drought-deciduous in summer, surviving on starch reserves stored in a subterranean tuberous caudex (stem). Short-leaved dudleya typically occurs on shallow sandy soils that overlay a cemented sandstone hardpan. These soils where the dudleya grows are frequently shallow that the underground stem will grow downward for a centimeter or so and then hit the hard pan and then continue growing horizontally along the surface of the hardpan layer (Dodero personal observation). In the thin soil areas the stem of the short-leaved dudleya can be very irregular in shape. Annual growth is initiated after the first significant fall rains and the plants grow actively through early April as long as soil conditions are moist. After growth is initiated, dry periods of several weeks in mid-winter can cause the plants to cease growth and become dormant for the season (Dodero 1995). In some cases even if

additional rains fall later in the winter or spring, the plants will not respond. This drought dormancy effect seems to be most common in smaller plants. Larger plants will usually maintain their leaves unless drought conditions are prolonged with higher than normal temperatures and low humidity. This dormancy response can lead to the mistaken determination that the plants have died or did not occupy a particular location because they were missed during the active portion their life cycle in a given year at a particular location. Short-leaved dudleya can begin flowering as early as late April and continue flowering through early June, with seed set occurring in late June and July. Short-leaved dudleya generally flowers later in the season than populations of the closely related Blochman's dudleya (*Dudleya blochmaniae* ssp. *blochmaniae*) elsewhere in the County (Moran 1951). Populations of short-leaved dudleya on Carmel Mountain also begin to flower somewhat earlier than non-specific populations at Torrey Pines State Park, where conditions are somewhat more mesic due to longer lasting fog cover (Dodero personal observation).

Census numbers generated through the MSCP monitoring program for the three subpopulations of short-leaved dudleya on Carmel Mountain show an increase in the number of flowering individuals in 2001 from the two previous years (City of San Diego 2001). Approximately 66,637 individuals were found in 2001, 23,500 in 2000, and 27,000 in 1999. These numbers likely reflect responses of the populations to the timing and amount of rainfall each of those years and probably do not indicate an actual increase in population numbers in light of the continued disturbance and ongoing weed invasion. In 1999 and 2000 rainfall was well below average and long dry periods of up to several weeks occurred in midwinter. As described above this type of weather pattern is not favorable for most plants to flower. In the 2001 season even though rainfall was still below normal, the rains that did occur were well spaced and effective and this probably led to a greater number of flowering plants than in previous years.

Potential pollinators of short-leaved dudleya which have been seen visiting flowers include bee flies (Bombyliidae), hover flies (Syrphidae), soft-winged flower beetles (*Dasytes* sp.; family Melyridae), honey bees (*Apis mellifera*), bumble bees (genus *Bombus*), and digger bees (family Anthophoridae). The seeds of the short-leaved dudleya are very small, approximately 0.8 millimeter in length and are generally dispersed by wind and water. Seedlings of short-leaved dudleya are frequently seen aggregated where water collects from small sheet-flooding events across the sandy surface mesa top. Also dried inflorescences of this species have been observed blowing across the sand on windy days after they have become detached from the parent plant. This presumably disperses seed as well (Dodero 1995).

The percentage of flowering individuals in a season is correlated with the amount and frequency of rainfall during the winter and early spring. Well-spaced rains throughout the winter, at one- to two-week intervals, leads to a greater number of flowering plants than in dry years or when long dry periods occur in the middle of the normal rainy season. Small plants typically do not flower in a dry year, but with above average or well-spaced rains, the same plant is capable of successful reproduction (Dodero 1995). In any given year only 10 to 30 percent of the individuals in a population will flower. Population estimates made from flowering individuals alone will significantly underestimate the total number of plants in a population. Reproduction is primarily by seed; however, short-leaved dudleya is also capable of vegetative reproduction via detached leaves both in nature and in cultivation (Dodero 1995). Within one to three weeks after leaves are removed from the plant, they develop roots at the petiole base and are ready for planting.

2. Existing locations of Short-leaved Dudleya

The five remaining natural populations of short-leaved dudleya are found on sandstone mesas of the Del Mar and La Jolla region of San Diego County. The terrestrial natural community of small-leaved dudleya is the southern maritime chaparral defined by the CDFG. The largest populations of short-leaved dudleya are found in the main portion of Torrey Pines State Park and within the Carmel Mountain Preserve. Smaller populations are found at Crest Canyon in Del Mar Heights, Skeleton Canyon at UCSD, and the Torrey Pines State Park extension north of Peñasquitos Lagoon. All three subpopulations have suffered from past and ongoing disturbances such as road grading, off-road vehicle, horse, bicycle, and foot traffic.

Photograph 8-3: Road Bisecting the Short-Leaved Dudleya Habitat (Subpopulation 3)

Photograph 8-4: Horse Hoof Imprint in Cryptogamic Crust

Photograph 8-5: Bicycle Tire Tracks and damaged Cryptogamic Crust

Damage to the dudleya areas has been particularly severe when vehicles have been driven through the habitat during rainy periods when soils and cryptogamic crusts are most easily damaged.

Photograph 8-6. Tire Ruts and Damaged Cryptogamic Crust at the Short-Leaved Dudleya Subpopulation 1

Although access is more restricted since surrounding development has occurred, impacts from vehicles, bicycles, horse, and foot traffic is ongoing and this has an adverse effect on the dudleya by directly crushing individuals. In addition, these disturbances are damaging and removing the surrounding cryptogamic crust, and this allows and promotes weed invasion once the crust is broken by disturbance.

Photograph 8-7. Weed Invasion into Short-leaved Dudleya Habitat after Disturbance from Pocket Gophers

After the initial disturbance occurs, pocket gophers frequently move into the area to feed on non-natives and the gopher burrowing promotes additional weed growth. The gopher disturbance then causes further weed invasion as non-native annuals invade the disturbed soils (RECON 1999). This disturbance and weed invasion trend must be reversed to ensure the long-term viability of short-leaved dudleya. Access by illegal off-road vehicles is still possible from the SDG&E access road. Bicycle, hikers, and horse use is uncontrolled and traverses short-leaved dudleya habitat. A high priority management task is to construct a lockable gate and restrict vehicle access to authorized vehicles only.

3. Goals of Habitat Management and Enhancement For Short-leaved Dudleya on Carmel Mountain

The goals of this Plan are to:

a. Eliminate vehicle, horse, and foot traffic disturbance of short-leaved dudleya habitat.
b. Restore the associated disturbed habitat in and around the three known subpopulations of short-leaved dudleya within the Carmel Mountain Preserve.
c. Maintain and expand self-sustaining populations of short-leaved dudleya within the Carmel Mountain Preserve to ensure their long-term existence.
d. Close and restore roads that bisect short-leaved dudleya habitat.
e. Preserve, protect, restore, and enhance sandstone terraces of Carmel Mountain dominated by ashy spike-moss and other cryptogamic species.
f. Establish new populations with a minimum of 10,000 short-leaved dudleya on appropriate sandstone terraces on Carmel Mountain.

To successfully attain the goals outlined above, the following management actions must be implemented:

- Reroute foot, bike, and horse trails around existing subpopulations of short-leaved dudleya and potential population expansion areas.

- Close roads that bisect existing habitat by implementation of the proposed trail and road closure program included in this document and through future cooperative agreements with SDG&E and private inholding landowners.
- Enter into an MOU between the City of San Diego and CDFG to allow for collection of 5 percent or less of the seed crop from the Carmel Mountain population annually for a period of approximately 10 years.
- Germinate seed to produce plants for captive seed production.
- Use propagated seed to directly seed appropriate restoration and enhancement sites.
- Propagate short-leaved dudleya from seed to grow mature plants for translocation into existing and new population sites.
- Repair of tire ruts with hand tools in areas where repair activities will not adversely affect existing sensitive species or cryptogamic crusts.
- Implement an exotic plant control measure in short-leaved dudleya habitat. Control measures can include hand removal using cutting devices that minimize soil disturbance, the use of leaf blowers/vacuums to remove weed seeds from cryptogamic crust/dudleya habitat areas and limited herbicide spraying where sensitive resources including the short-leaved dudleya will not be impacted. Replanting/reseeding with site appropriate natives grown from locally collected seed.
- Collect, propagate, and broadcast appropriate species of native seed into restoration sites where weeds are under control.

4. Habitat and Population Enhancement

Expanding the numbers of short-leaved dudleya could include the use of several propagation techniques including hand broadcasting of seed collected from the natural populations, propagation and dispersal of seed produced from plants maintained at a growing facility in the vicinity of the Preserve, and translocation of nursery grown plants. In addition, exotic species shall be controlled and replaced with native species by hand broadcasting seed. Three sites have been selected to serve as the enhancement areas for short-leaved dudleya (Figures 8-1a and 8-1b). The three areas correspond to the subpopulations identified in the City of San Diego MSCP monitoring program report (City of San Diego 2001).

a. Site Protection

The first priority for the three areas is to protect them from further disturbance from vehicle, horse, and foot traffic as outlined in the trail and road closure program. A locked gate should be installed at the southern terminus of the SDG&E access road to prevent continued unauthorized vehicle traffic into the Preserve. The roads/trails that bisect subpopulations two and three on Carmel Mountain are proposed for closure or rerouting of the trails around the short-leaved dudleya habitat. The SDG&E access road that runs immediately adjacent to subpopulation 1 is not proposed for closure at this time. This road should be considered for closure if alternate access to SDG&E transmission towers and the private inholdings can be arranged through negotiations between the City, the landowners, and SDG&E. Barriers such as split-rail fencing could be installed along the edge of the road/trail to protect subpopulation 1. The existing roads/trails that go through subpopulations 2 and 3 are proposed for closure and fencing barriers and signage can be placed at appropriate locations to discourage foot and vehicle traffic.

If protective fences or barriers are installed, the location and design of the fences should be carefully considered so that the fence installation and maintenance activities do not impact the dudleya populations or the cryptogamic crusts in the vicinity.

b. Site Rehabilitation and Maintenance

Because short-leaved dudleya will be established in existing (albeit somewhat disturbed) habitat occurring on intact soils, no soil testing will be necessary. The sites have non-native weedy species particularly annual grasses that must be controlled and replaced by native species. No native species are anticipated to be displaced by this restoration project, which is designed to enhance the site. The intact sites most likely support the mycorrhizal associations important to the successful establishment of native plant species.

Exotic plants will be controlled throughout the length of the program. Non-native species will be removed primarily using hand tools, although some plants may need to be controlled by Roundup® or another appropriate herbicide sprayed by a licensed pesticide applicator under the supervision of the project biologist. As exotics are removed, these areas will receive hand-broadcast native seed collected including the short-leaved dudleya from on-site in order to enhance the quality of the habitat. Native seeds other than short-leaved dudleya will not be placed directly in the dudleya planting sites in order to avoid competition early in the establishment process. Also, seeds will not be raked into the soil, as this action enhances weed germination and competition. The use of supplemental water for native species other than the dudleya is not anticipated because native seeds will be broadcast during the winter rainy season. The restoration sites should be actively maintained for a minimum of five years depending on funding. If adequate money is not available in the early years, then the focus should be placed on limiting disturbance to habitat and restoration activities may be extended for a longer period at any particular site. Maintenance will commence following placement and establishment of dudleya seed, transplanted adults, and leaf cuts, if they are used. Maintenance activities will include continued control of exotics and visual inspections to identify incipient problems such as herbivory or vandalism. The monitoring biologist shall direct weeding crews to remove weeds and determine which plants require control during the five-year maintenance period. The need for weeding is expected to decrease substantially by the end of the five-year period, provided successful habitat restoration has been achieved. The proposed weeding schedule is seen in Table 8-1.

Trash Removal

Trash in the preserve areas shall be removed once every month, if present. The installation of a locked gate at the entrance to the SDG&E access road should substantially decrease illegal dumping.

Maintenance of Fencing and Signs

All fencing and signs if installed, shall be checked and repaired as necessary once every month. Any persons found willfully damaging the habitat within the preserves, including but not restricted to trash

TABLE 8-1
APPROXIMATE MAINTENANCE SCHEDULE FOR THE SHORT-LEAVED DUDLEYA RESTORATION AND ENHANCEMENT PROGRAM

Type/Task	Year 1	Year 2	Year 3	Year 4	Year 5
Site protection	Monthly	Quarterly	Quarterly	Quarterly	Quarterly
Weed control	As-needed	As-needed	Quarterly	Three times a year	Twice a year
Trash removal	Monthly	Quarterly	Quarterly	Quarterly	Quarterly
Planting-seeding	Winter	Winter	Winter	Winter	Winter
Irrigation	As-needed by hand	As-needed by hand	As-needed by hand	–	–

dumping, ORV activity, trespass, plant removal, and destruction of barriers, shall be prosecuted to the full extent of the law.

Dudleya Seed Collection

After an MOU agreement for seed collection of this state listed species has been negotiated with CDFG, seeds from individual short-leaved dudleya found in the three subpopulations on Carmel Mountain should be collected annually. Seeds from individuals of short-leaved dudleya found in the populations on Carmel Mountain will be collected in the summer. Dried inflorescences should be collected and placed in paper envelopes, which allow for the evaporation of residual moisture to prevent molding. Seeds are then stored in a cool, dark location to prevent desiccation and maintain viability. *Dudleya* seeds remain viable for many years under these conditions (Dodero 1995) and germination tests using seeds from *Dudleya multicaulis*, a closely related species, indicate no significant reduction in viability over a two-year storage period.

The seed would be used to propagate plants at a nearby growing facility for later translocation to the Preserve and also to grow plants that will used to produce seed for direct application to the restoration sites and for dispersal into appropriate but currently unoccupied areas of the Preserve (see Figures 8-1a and 8-1b).

To ensure the maintenance of genetic diversity in the enhanced and newly created subpopulations, seed should be collected from individuals in each subpopulation. In the absence of any genetic information it is probably the best strategy to keep seeds and plants from each subpopulation separate to maintain any genetic differentiation between the subpopulations. Plants propagated from these seeds should only be used in the same subpopulation area that they originated from.

For newly created populations disjunct from the existing sites, plants and seeds from the three different subpopulations could be mixed to create as genetically diverse populations as possible. In theory then the created populations would have the best chance of having at least some individuals that are adapted to the varying types of conditions that may be present at the proposed creation/expansion sites. Past experience with translocation of Blochman's dudleya suggests that plants will do well at the new sites as long as they are properly planted and herbivory is not too severe and weeds are controlled (RECON 1996, 2001).

Propagation of Short-leaved Dudleya

To propagate short-leaved dudleya for translocation and seed production the following methods should be used. Salvaged soil collected on-site can be placed in standard greenhouse flats to a depth of approximately one inch. Flats should be filled with soil that has a higher clay content than pure sand. The clay is a more stable growing medium than sand and will be easier to transplant into the restoration sites. Clumps of plants grown in sand have a tendency to break apart and will not transplant well.

Soil could be salvaged from nearby locations with the same soil type that are slated for development. Another option would be to salvage soil from the cut edge of the mesa adjacent to the park where the soil has already been disturbed by grading activities.

The dried dudleya fruits can be broken apart by hand to release the seeds that are then sprinkled on the surface of the moist soil. Because of their small size the short-leaved dudleya seeds should not be not covered with any soil. The seeds should be immediately watered with a fine mist several times a day to keep them continuously moist for a period of approximately two weeks although in the cool fall and winter seasons most viable dudleya seeds should germinate within one week. To produce plants that will attain the greatest possible size during the first growing season short-leaved dudleya seed is best sown after the first cold front of the season has past, usually in late October. Plants started at that time have the potential

to reach flowering size in cultivation in approximately six months.

The sowing of the seed in the flats should be covered with shade cloth to reduce evaporative water loss from the soil and to minimize mechanical disturbance from watering. Each flat requires weeding as needed throughout the growing season. Supplemental watering should be given as needed during dry periods and small seedlings should never be allowed to dry out during the growing season. By late April, supplemental watering should be discontinued to allow the plants to enter their normal dormancy cycle, which starts at the onset of the summer drought.

If flats are intended for translocation into sites with thin soil, the amount of soil placed in the flats can be adjusted to accommodate the depth of the soil at the translocation site. The soil in the flats should always be somewhat more shallow than the soil at the translocation site. The reason for this is that the translocated plants should be planted flush with or slightly below the existing soil surface to ensure that the newly translocated plants are in a slightly depositional rather than an erosional environment. If the underground stems are exposed above the soil surface by erosion the plants are likely to die. Short-leaved dudleyas and closely related species are adapted to live in areas where there is slow deposition of sand and clay (Dodero 1995). The plants can keep pace with the deposition of soil by elongating their stem upward through the soil. As long as deposition of soil is not too rapid, the plants can grow well in this type of environment.

The goal of any translocation or habitat restoration plan is the establishment of a self-sustaining population with a minimum population size which enables the species to retain the genetic resources necessary to adapt to changing environmental conditions (Guerrant 1996). To achieve the goal of creating a self-sustaining population, up to three establishment methods could be used: hand broadcasting of dudleya seed to weed-free areas, planting individuals germinated from seed collected on-site or if necessary planting of whole leaves that develop into new plants after a period of a few weeks. Each method of establishment, whether by seed, cuttings, or transplants, may have drawbacks, depending on site-specific conditions (Guerrant 1996).

Previous restoration experience with Blochman's dudleya, a closely related species, indicates propagation of seed-grown plants in cultivation results in the greatest survivorship of seedlings (approximately 90 percent) over direct seeding (approximately 10 percent). Because of the very thin soils or the presence of intact cryptogamic crusts at some of the enhancement sites, flats of cultivated seedlings may not be able to be planted in many locations that otherwise have high restoration potential. In thin soil areas direct seeding may be the only method available to establish plants because flats of seedlings will not be able to be successfully translocated into soil only one centimeter thick. Direct seeding should also be used where planting of cultivated short-leaved dudleyas would impact existing cryptogamic crusts.

Another option to solve the problem of thin soils is to bring in relatively small amounts of soil to replace soil lost through road grading and erosion in subpopulations 2 and 3 on Carmel Mountain. Small amounts of salvaged sandy soil could be collected from the graded edge of the Neighborhood 8A park where it abuts the Preserve and this soil could be thinly spread across the graded road areas that have little or no soil. Soil could be placed up to one inch deep to restore growing areas for the dudleya. At this maximum depth the soils would still be too thin to support shrubs but the short-leaved dudleya is adapted to these conditions. The intent is to establish plants wherever the habitat is appropriate within the restoration sites using the methods and criteria outlined above.

Introduction of Other Plant Species

The following herbaceous species are suitable for use in restored and enhanced short-leaved dudleya habitat: Cleveland's shooting stars, dot-seed plantain, pygmy

weed, skunkweed, spineflower, herba impia, popcorn flower, and everlasting nest straw. Other associated herbaceous species may also be suitable for revegetation around newly created dudleya populations. All native plant species intended for reintroduction into the restoration and enhancement sites should be collected within the Preserve and hand broadcast. Since the dudleya habitat areas to be restored relatively small, sufficient seed can probably be collected in the vicinity of Carmel Mountain for hand broadcast. Seeds of other plant species directly into newly planted short-leaved dudleya patches to keep competition low. Seeding should be conducted in the fall or early winter just prior to anticipated rainfall. Timing seed dispersal to coincide with rainfall events reduces the amount of time the subject to herbivory and fungal attack and therefore is likely to increase germination success.

Irrigation

Hand irrigation for new seedlings and transplants will likely be needed the first season. If dry periods longer than approximately two weeks occur (or if plants look desiccated) after seedlings have germinated or flats of seedlings have been planted, supplemental water will be needed to ensure the greatest survivorship of individuals. Watering of seedlings and transplants should be done gently to minimize any soil disturbance that can uproot seedlings or expose the stem of the plants to the air. The plants should be kept moist until natural rainfall occurs. If natural rain events occur at regular intervals less supplemental watering will be required.

Site Selection Criteria for New Populations

There are a number of characteristics to consider when selecting a translocation site. Fiedler and Laven (1996) suggest these selection criteria fall into four general categories: physical, biological, logistical, and historical. Physical characteristics for site selection can be straightforward and typically focus on soils and landscape characteristics. Biological criteria are considered to be the ecological characteristics of a species. Translocation sites should be selected based on the presence of appropriate habitat parameters, including similar plant community structure and successional stage. In addition, potential competitors of the plant species being translocated, including weeds, should be identified and a plan developed and implemented for the control of these other species. Logistical criteria to consider when choosing the translocation site should include how well the site can be protected from unauthorized human access, as well as the level of difficulty in accessing the site for monitoring and remediation efforts. Historical selection criteria include two issues: (1) the use of currently occupied versus potential habitat and (2) consideration of a species evolutionary history, including its specific habitat requirements. Knowledge of how the habitat, occupied by the species, changes over time and how new habitat arises and becomes occupied by the plant is important to the success of restoration efforts. The site selection criteria outlined by Fiedler and Laven (1996) are reflected in the choice of the proposed population creation sites depicted in Figures 8-1a and 8-1b.

Guerrant (1996) performed modeling experiments on a number of rare plant species for which reintroduction programs were implemented. He found the risk of population extinction is greatly reduced if plants of even slightly larger than seedling size are used in a translocation program. Guerrant also found that the size of the created populations after 10 years is strongly correlated with the size of the plants used. The use of the largest individuals of a species resulted in the largest population size. These size factors have been taken into account in designing the methods for propagating and establishing a new population of small-leaved dudleya at Carmel Mountain.

In addition, Guerrant (1996) points out that one of the most serious problems associated with reintroduction is a loss of genetic

diversity. Research has shown that reduced population size can rapidly result in the loss of genetic variability. One way to avoid the loss of genetic diversity is to rapidly expand the size of the newly established population (Guerrant 1996). By increasing the number of individuals soon after the population is established, much of the genetic variability present in a population can be maintained. The natural populations of short-leaved dudleya are found on hard sandstone terraces, a mixture of sandstones and clay with iron concretions that have formed by weathering of the rock. The dominant plants in dudleya habitat include ashy spike-moss and herbaceous species. The proposed creation sites have similar soils and plant communities to those found at the natural population sites nearby.

Dodero (1995) notes that the range of this and other closely related species have probably expanded and contracted throughout the evolutionary history of the group, as areas of appropriate habitat have been exposed and subsequently eroded. The mosaic of occupied and potential dudleya habitat changes over time and probably causes populations to come into contact or become isolated as habitat areas shrink and then expand. Limited dispersal capabilities of short-leaved dudleya reduces the chances that suitable habitat nearby will be colonized naturally.

Monitoring

As mentioned previously, the short-leaved dudleya are part of an ongoing MSCP monitoring program. The goals of the annual monitoring program are to: (1) document ecological trends, (2) evaluate the effectiveness of management activities, (3) provide new data on species populations, and (4) evaluate the indirect impacts of land uses and construction. The following are additional monitoring recommendations for the restoration and enhancement program for short-leaved dudleya on Carmel Mountain intended to meet these stated goals.

With careful monitoring, researchers can detect changes in managed and unmanaged populations and communities over time (Primack 1996; Sutter 1996). Monitoring can be used to obtain basic biological information regarding life history traits of species including seed production, pollination, herbivory, dispersal, and seed and plant dormancy (Sutter 1996). With these goals in mind, the restored and newly created populations will be monitored for a minimum of five years. Monitoring activities will include:

- Photographing plots from permanent locations during the active growing period of short-leaved dudleya (February);
- Collection of quantitative data on total counts of short-leaved dudleya individuals in early February (MSCP Biological Monitoring Plan);
- Collection and identification of insect pollinators from the existing population of short-leaved dudleya at Carmel Mountain and the new population sites in May and June to assess on-site pollinator diversity and to ensure sufficient preservation of open ground habitat for pollinators.
- Collection of quantitative data on total counts of flowering individuals at the new population sites in May and June.
- Collection of detailed qualitative and quantitative information regarding the success of exotic species eradication efforts at the restoration/translocation sites each year in spring. The extent of exotic and native species will be quantified using global positioning system (GPS) technology and the resulting changes in the distribution of these plants, including the dudleya, which will be monitored throughout the five-year monitoring period.

In addition, seedlings established at new population sites will be monitored for collection of detailed data on dudleya growth rates. A minimum of 40 seedlings will be marked and followed through their development from germination through five consecutive growing seasons. Data to be recorded includes number of rosette leaves,

maximum length of rosette leaf, number and height of inflorescences, and presence of seed. Leaf measurement data will be recorded annually during late February-early March when the plants have reached their maximum leaf size for the season. The number and height of the inflorescences will be recorded annually in late April-early May during the flowering period.

Based on growth data recorded for variegated dudleya and Blochman's dudleya, short-leaved dudleya seedling plants germinated in the field are not expected to reach flowering maturity under natural conditions until at least the third season of growth (Dodero 1995).

All monitoring activities should be conducted with care to minimize impacts to short-leaved dudleya and cryptogamic crusts caused by foot traffic. Even occasional foot traffic can have negative effects on habitat quality when cryptogamic crusts are broken and weeds invade a site as a result of disturbance. Land managers should evaluate the effects of monitoring on habitat quality and adjust the monitoring program schedule and tasks accordingly if damage is occurring.

Planting and Seeding

- After initial planting, the site will be checked twice a week by the project biologist for the first two months, once a week for the next four months, and monthly thereafter to determine if seeding and plantings are successful or if remedial measures including hand irrigation is needed.
- Other site problems such as vehicle damage and erosion shall be reported to the City of San Diego and the Wildlife Agencies with recommended remedial measures.

Success Criteria. The success of the population expansion program should be evaluated in light of four goals, which include abundance, extent, resilience, and persistence (Pavlik 1996). The goal of maintaining abundance can be fulfilled by introducing large numbers of plants and propagules into the new site. Extent refers to the number and distribution of populations of a particular species. Resilience is maximized by maintenance of genetic variation, resistance to environmental perturbation, and ability of the plant to become dormant during unfavorable conditions. Persistence of populations is more likely when there is microhabitat variation within the translocation site and the natural community which the species occurs in is maintained. The goal of the population expansion project is to create viable reproducing populations of short-leaved dudleya which are large enough to survive environmental perturbations and persist for the foreseeable future. Created populations should consist of a minimum of approximately 10,000 individuals. Specific success criteria have been established for enhancing and expanding the numbers of short-leaved dudleya on the Carmel Mountain Preserve. These criteria should be the success goals required of the consultant, agency, or non-profit organization who is charged with implementing the short-leaved dudleya population expansion project:

1. If, at end of the five-year period, the population of short-leaved dudleya at the new sites equals or exceeds 10,000 individuals (all age classes), with a minimum of 2,500 flowering plants (in any of the five years) then the expansion effort shall be deemed successful. No further transplanting, seeding of short-leaved dudleya, or other native plant species would be required. Monitoring and control efforts for exotic plants shall continue in perpetuity. Since the short-leaved dudleya is a state-listed plant, the project biologist in coordination with the City of San Diego and CDFG plant ecologists will conduct an annual review to assess the effectiveness of restoration and weeding efforts. The long-term management of the translocation/ restoration areas will be performed in accordance with other management activities presented in this Management Plan for Carmel Mountain and Del Mar Mesa Preserves.

c. Reports

Annual reports will be submitted by whatever group is chosen to implement the population expansion project by September 30 of each year of the program. Reports will include the results of control efforts for exotic plants, native seed collection and seeding programs, photodocumentation of the restoration site from permanent locations taken annually, total counts of short-leaved dudleya actively growing each year, total counts of the number of flowering individuals, and annual assessments of the general health and condition of translocated short-leaved dudleya. Annual reports will be submitted to the City of San Diego and the CDFG Natural Heritage Division-Plant Conservation Program.

5. Restorationist Qualifications

The restoration project biologist should have a minimum of five years of general restoration experience in coastal southern California and a minimum of three years of experience with the monitoring, propagation, translocation of short-leaved dudleya or closely related species. The project biologist should be able to demonstrate an understanding of the special growing requirements of short-leaved dudleya as they relate to the restoration and enhancement of this state listed endangered species.

B. Vernal Pools

1. San Diego Mesa Hardpan Vernal Pools-Recovery Criteria and Goals

San Diego mesa hardpan vernal pools are shallow, isolated, ephemeral wetlands. The microtopography surrounding vernal pools often consists of small mima mounds or hummocks. Vernal pools fill with water during winter rains and the water evaporates after the rains cease. Plants in vernal pools may be aquatic or may germinate following the drying of the pool. San Diego mesa hardpan vernal pools have a characteristic suite of plant and animal species. Hardpan vernal pools are primarily found north of Otay Mesa (Holland 1986). Vernal pools are considered to be sensitive habitat by local, state, and federal governments, and it is estimated that over 95 percent of the vernal pool habitat in San Diego County has been destroyed (Bauder 1986).

The Recovery Plan for Vernal Pools of Southern California (USFWS 1998) describes actions USFWS believes are needed to recover or protect the federally listed species that occur in vernal pools. The Recovery Plan addresses three listed vernal pool species that occur within the Carmel Mountain or the Del Mar Mesa Preserve: San Diego fairy shrimp, San Diego button-celery, and San Diego mesa mint.

The criteria and goal of the Recovery Plan is to increase and stabilize the populations of these species so they can be downlisted from endangered to threatened. Population trends must be shown to be stable or increasing for a minimum of 10 consecutive years prior to the USFWS considering the reclassification of the listed species. Monitoring should continue for a period of at least 10 years following reclassification to ensure population stability.

This management plan addresses three actions identified by the USFWS as being needed to move the populations toward recovery:

a. Conduct surveys and research essential to the conservation of these species (described on p. 69 of the Recovery Plan),
b. Where necessary, reestablish vernal pool habitat to the historical structure and composition to increase genetic diversity and population stability (described on p. 71 of the Recovery Plan), and
c. Manage and monitor habitat and listed species (described on p. 72 of the Recovery Plan).

As identified in the Recovery Plan, this Vernal Pool Habitat Restoration section of this Management Plan addresses the reestablishment of the physical and biological characteristics of vernal pool habitat such as topography, hydrology, soil properties, water quality, nutrient cycling, species diversity, and species interactions to what they were prior to disturbance.

2. Goals of Vernal Pool Restoration and Enhancement Program on the Carmel Mountain and Del Mar Mesa Preserves

The restoration plans presented here for vernal pools on Carmel Mountain and Del Mar Mesa are conceptual. Additional detailed information should be gathered prior to implementation of any restoration activities for vernal pools including conducting focused surveys for listed fairy shrimp and listed and sensitive vernal pool plants. In addition, detailed topographic information should be gathered for each proposed restoration area and this data should be used to create a grading plan for implementation. Sensitive species survey data and topographic information will be included in a detailed restoration plan to be prepared for each site and approved by the wildlife agencies and land managers prior to implementation.

The goals of this Plan are to:

a. Preserve, protect, and restore vernal pool habitat in the Carmel Mountain and Del Mar Mesa Preserves.
b. Restore natural vernal pool functions and values in degraded and damaged pools.
c. Minimize and try to eliminate vehicle, horse, and foot traffic disturbance of vernal pool habitat.
d. Maintain and expand self-sustaining populations of vernal pool plant and animal species including listed and sensitive taxa as appropriate within the Carmel Mountain and Del Mar Preserves to ensure their long-term existence.
e. Restore the associated disturbed upland habitat around the vernal pools within the Carmel Mountain and Del Mar Mesa Preserves to reduce weed invasion into the vernal pools.

To successfully attain the goals outlined above, the following management actions must be implemented:

- When possible, reroute foot, bike, and horse trails around existing vernal pool habitat areas.
- Close and restore roads that bisect vernal pool habitat in locations that are not part of the designated recreational trails system or roads that provide access routes for SDG&E and private inholdings.
- Erect wooden fences and repair existing barriers to discourage off-trail recreational travel.
- Recontour depressions to a more natural shape in roads and trails that are not part of the designated trail system.
- Repair tire ruts with hand tools in areas where repair activities will not adversely affect existing sensitive species or adjacent cryptogamic crusts.
- Collect 5 percent or less of the seed crop from the Carmel Mountain and Del Mar Mesa vernal pool plant species for redistribution into restored pools.
- Use collected seed to inoculate restored pools with appropriate vernal pool flora.
- Control exotic plants through hand removal from pool basins and control weeds in surrounding uplands.

3. Vernal Pool Resources on Carmel Mountain

In the Carmel Mountain Preserve, mima mound topography does not exist. Vernal pools on Carmel Mountain occur in depressions in openings in the surrounding maritime chaparral community and adjacent

to openings around mesic meadows, seeps, and ashy spike-moss-dominated areas (Figures 8-1c and 8-1d). Species dominating these pools are woolly marbles (*Psilocarphus brevissimus*), stone-crop (*Crassula aquatica*), flowering quillwort (*Lilaea scilliodes*), and water starwort (*Callitriche marginata*) (Table 8-2). Less common vernal pool species include the Orcutt's brodiaea, chaffweed (*Centunculus minimus*), waterwort (*Elatine brachysperma*), and California adder's tongue (*Ophioglossum californicum*). Additional generalist wetland species present on Carmel Mountain include pale spike-rush (*Eleocharis macrostachya*), mariposa rush (*Juncus dubius*), and toad rush (*J. bufonius*). Areas that can best be described as mesic meadows and seeps, dominated by mariposa rush and blue-eyed grass (*Sisyrinchium bellum*), transition into vernal pool habitat and the herbaceous communities dominated by ashy spike-moss, shooting stars, dot-seed plantain, popcorn flower, wavy-leaved soap plant, and other herbaceous species as well as southern maritime chaparral vegetation.

No listed vernal pool plant species are historically known from the Carmel Mountain. Redding soils, that are known to support populations of San Diego mesa mint in other coastal mesas in central San Diego, are limited in extent on Carmel Mountain (see Figure 3-2) and are located to the southeast of the main vernal pool complex on the western and central portions of the mesa top. The primary area of vernal pools on Carmel Mountain are found on Carlsbad gravelly loam soils located above the impermeable sandstone terrace. Like San Diego mesa mint, San Diego button celery and spreading navarretia are not known to have been present historically on Carmel Mountain.

Sensitive animal species associated with vernal pool habitat on Carmel Mountain include the listed San Diego fairy shrimp discussed below, as well as the two-striped garter snake (*Thamnophis hammondii*) and western spadefoot (*Spea hammondii*).

a. Endangered Vernal Pool Species on Carmel Mountain

San Diego Fairy Shrimp (*Branchinecta sandiegonensis*)

The San Diego fairy shrimp is federally listed as endangered and is covered by the City of San Diego's Multiple Species Conservation Program (MSCP 1995). This species is restricted to vernal pools in coastal southern California and south to northwestern Baja California, Mexico (USFWS 2000). The life cycle of fairy shrimp is relatively simple, with larvae hatching out of dormant cysts after being covered with water for a prescribed period of time, developing into adults, and mating and laying eggs before the pool dries. The development time is influenced both by the water temperature and the species-specific responses to environmental cues including water chemistry. San Diego fairy shrimp are found in the spring in vernal pools and other ponded areas that are generally less than 30 centimeters deep. This species takes between 3 and 8 days to hatch and development to the adult stage takes between 7 and 20 days.

4. Current Status of Vernal Pools on Carmel Mountain

Approximately 93 vernal pool depressions and seeps have been mapped on Carmel Mountain. Vernal pools mapping for this plan was provided by the City of San Diego and revised in part by RECON (see Figures 8-1c and 8-1d). Vernal pools and seeps on the Torrey Surf property were mapped by Helix Environmental Inc. The majority of the pools are located in the southwestern portion of the mesa top (see Figures 8-1c and 8-1d). The vernal pools of Carmel Mountain have suffered different levels of disturbance from road grading, vehicle traffic, particularly damaging during wet periods, and creation of new trails by

mountain bikes and equestrian use. Levels of damage to the pools range from relatively undisturbed (a few pools) to the other extreme where pools have been virtually eliminated by road grading and trail use. The relatively undisturbed pools are located away from roads and trails in openings in the maritime chaparral vegetation. Other pools have single or multiple sets of tire tracks, but otherwise still support vernal pool indicator species such as woolly marbles. In some cases depressions along the graded roads that have been impacted by vehicle traffic each wet season and have no or few vernal pool plant indicator species, although the areas have the necessary hydrology to support native vernal pool species. Western spadefoot toad tadpoles have been observed in depressions located in roads and the tadpoles have been impacted in the past by unauthorized vehicle traffic. In some cases very small remnant populations of wooly marbles are found in some of these the road depressions. Water starwort can be found growing in and along the edges of the road where water seeps along the hardpan from the somewhat higher elevations on Carmel Mountain.

The maritime chaparral areas on the mesa top are gently tilted to the west and south and these higher areas act as water catchment areas during the wet season. This rainwater infiltrates the topsoil and then eventually reaches the impervious hardpan. Rainwater appears to seep and percolate downhill along the upper surface of the hardpan as subsurface flows into the pools located in flatter portions of the mesa near the southwestern and southern periphery of the cemented sandstone strata. These seeps often stay wet well after rainfall has stopped. This subsurface flow may increase the amount of ponding in the some of the pools beyond that apparent from the visible surface watershed of individual pools. Roads and trails that have removed all of the topsoil may have the effect of redirecting or channeling flow in unnatural patterns so that some pools may not be ponding much as they once did. Depressions located in graded roads may pond for longer periods because the road grading has either created or deepened existing depressions. In addition the compacted roads possibly direct both more surface flows into these areas than would occur naturally.

Vernal Pool Restoration Program for Carmel Mountain

Lands formerly supporting San Diego mesa hardpan vernal pool habitat, eliminated by topographic disturbance and the loss of hydrologic ponding characteristics, have the

TABLE 8-2
VERNAL POOL PLANT INDICATOR SPECIES FOR THE CARMEL MOUNTAIN PRESERVE

Plant Species	Type
Orcutt's brodiaea *Brodiaea orcuttii*	Annual, vernal pools and foothill springs
Water-starwort *Callitriche marginata*	Annual, vernal pools and moist openings
Chaffweed *Centunculus minimus*	Annual, vernal pool specialist in region
Stone-crop *Crassula aquatica*	Annual, vernal pools and ephemeral wetlands
Waterwort *Elatine sp.*	Annual, ephemeral wetlands, muddy shores
Pale spikerush *Eleocharis macrostachya*	Perennial, ephemeral wetlands
Mariposa rush *Juncus dubius*	Perennial, wet places
Toad rush *Juncus bufonius*	Annual, weedy native of ephemeral wetlands
Rush *Juncus triformes*	Annual, vernal pools and ephemeral wetlands
Flowering quillwort *Lilaea scilloides*	Annual, ephemeral wetlands, streams & lake edges
Grass poly *Lythrum hyssopifolia*	Annual, wet habitats
Water chickweed *Montia fontana*	Annual, vernal pool specialist in region
California adder's tongue *Ophioglossum californicum*	Annual, vernal pools and chaparral
Hooked navarretia *Navarretia hamata*	Annual, vernal pool specialist in region
Lemon canary grass *Phalaris lemmonii*	Annual, moist areas
Adobe allocarya *Plagiobothrys acanthocarpus*	Annual, shallow vernal pools and moist openings
Plantain *Plantago elongata*	Annual, vernal pools, saline and alkaline places
Dot-seed plantain *Plantago erecta*	Annual, shallow vernal pools and moist openings
Dwarf woolly-heads *Psilocarphus brevissimus*	Annual, vernal pool specialist
Woolly-heads *Psilocarphus tenellus*	Annual, vernal pool specialist
Bladder clover *Trifolium depaupertaum* var. *amplectans*	Annual, wet meadows, open alkaline or spring-moist heavy soils

List was compiled from RECON 1994 and Bauder and McMillan 1996.

NOTE: Vascular plant species known to occupy natural vernal pools in the Carmel Mountain region. Species identified as "vernal pool specialists" are found almost exclusively in natural vernal pools in the region.

potential to be restored. The vernal pools to be restored on Carmel Mountain will support vernal pool indicator species historically known to be present. Plants on the list of vernal pool indicator species (see Table 8-2) should be considered for reintroduction into restored vernal pools on Carmel Mountain.

Since the listed vernal pool plant species are not known to have occurred historically on Carmel Mountain no listed plant species are proposed for introduction to Carmel Mountain. Restored pools that do not currently support the federally listed San Diego fairy shrimp could be inoculated with shrimp cysts after reconstruction with USFWS approval.

Virtually all vernal pools on Carmel Mountain have been disturbed and these pools would all benefit from the proposed restoration program. The pools with the highest priority for restoration activities are located in and adjacent to roads and trails that are not part of the proposed trail system for Carmel Mountain (see Figures 5-2e-h). Restoration of pools and depressions present in and adjacent to roads and trails that are part of the proposed trail system have a lower priority for restoration due to potential conflicts with recreational uses and the necessity to maintain access routes for SDG&E and to private inholdings. Restoration of vernal pool resources in the SDG&E access roads would only be done if these roads are no longer needed by SDG&E or by private landowners to access their property.

The potential vernal pool restoration sites Carmel Mountain are located in the southwest and southern portions of the Carmel Mountain Preserve (Figures 8-1e-j). Each mapped pool is numbered in these figures and Table 8-3 provides corresponding recommendations for potential vernal pool restoration activities for each numbered pool. Figures 8-1e-j also depict potential trail system rerouting possibilities around vernal pools. This proposed rerouting is intended to minimize impacts of recreational uses to sensitive vernal pool resources. Only trails that cross through vernal pools not located in the SDG&E and private landowner access roads are proposed for rerouting.

Restoration activities that would be beneficial to individual vernal pools are briefly described in Table 8-3 including recommended weeding activities and topographic recontouring, if this restoration activity would benefit and restore more natural hydrologic conditions. The recommendation provided in Table 8-3 should be reevaluated at such time that a detailed restoration plan is prepared for each restoration site. In a few cases, previously mapped pools could not be relocated with certainty and this fact is also noted in Table 8-3.

Additional details and recommendations regarding establishment of vernal pool target species maintenance and monitoring schedules Implementation

5. Vernal Pool Resources on Del Mar Mesa

On Del Mar Mesa vernal pools occur in openings in the surrounding chaparral vegetation including chamise chaparral,

TABLE 8-3
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE CARMEL MOUNTAIN PRESERVE

Vernal Pool Number	Problems/Comments/Recommendations	Sensitive Species Present	Hand Tools	Heavy Equipment
1	Vernal pool inside road, recontour. *Revised mapping by RECON. On SDG&E access road.			√
2	Vernal pool inside road, recontour. *Revised mapping by RECON. On SDG&E access road.			√
3	Vernal pool inside road, recontour. *Revised mapping by RECON. On SDG&E access road.	*Branchinecta*		√
4	*Vernal pool was not located, as mapped by City of San Diego. On SDG&E access road.			√
5	Close the road, weed. *Revised mapping by RECON.			√
6	Vernal Pool inside road. Close the road, recontour. *Revised mapping by RECON.			√
7	*Vernal Pool was not located, as mapped by City of San Diego.			
8	Vernal pool inside road, recontour and weed. *Revised mapping by RECON.			√
9	Recontour and weed. *Revised mapping by RECON.		√	
10	Recontour and weed, many road ruts in the pool. *Revised mapping by RECON.		√	√
11	Vernal pool inside road, recontour. Currently on private land, and SDG&E access road.			√
12	Weeding is needed.			√
13	Weeding is needed. *Currently on private land.			
14	Weeding is needed.			
15	Weeding is needed. *Currently on private land.			
16	Weed and recontour. *Currently on private land.		√	
17	Weed and recontour. *Currently on private land.		√	
18	Vernal pool inside road, recontour and weed. *Revised mapping by RECON.			√
19	Vernal pool inside road, recontour and weed. *Revised mapping by RECON.			√
20	Weed and recontour, tire tracks in pool.		√	
21	Weed and recontour, tire tracks in pool.			√

TABLE 8-3
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE CARMEL MOUNTAIN PRESERVE
(continued)

Vernal Pool Number	Problems/Comments/Recommendations	Sensitive Species Present	Hand Tools	Heavy Equipment
22	Close the trail, and weed. Remove nearby trash. *Revised mapping by RECON.			
23	Weeding. *Revised mapping by RECON.			
24	Close the foot trail, and weed. *Revised mapping by RECON.			
25	Weed and recontour. Gopher activity present.		√	
26	Weed and recontour. Gopher activity present.		√	
27	Weed and recontour.		√	
28	Weed and recontour, tire tracks in pool.		√	
29	Weed and remove nearby trash.			
30	Vernal pool inside road, recontour. *Revised mapping by RECON.			√
31	Vernal pool inside road, recontour and weed. *Revised mapping by RECON.			√
32	Weed and recontour.		√	
33	Weed and recontour.		√	
34	Weed and recontour.		√	
35	Weed and recontour.		√	
36	Weed and recontour.		√	
37	Close the foot trail, and weed.			
38	Weed and recontour. *Revised mapping by RECON.			√
39	Weed and recontour.		√	
40	Weed.			
41	Close trail and weed.			
42	Weed. *Revised mapping by RECON.		√	
43	Close trail and weed. Heavy gopher activity.			
44	Close trail and weed. Heavy gopher activity.			
45	Weed. Vernal pool within large meadow of *Juncus* sp*, Hemizonia fasciculatum,* and *Sysrinchium bellum.*			
46	Weed and recontour. Vernal pool within large meadow of *Juncus* sp*, Hemizonia fasciculatum,* and *Sysrinchium bellum.*		√	
47	Weed. Vernal pool next to road.			

TABLE 8-3
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE CARMEL MOUNTAIN PRESERVE
(continued)

Vernal Pool Number	Problems/Comments/Recommendations	Sensitive Species Present	Hand Tools	Heavy Equipment
48	Weed. *Revised mapping by RECON.			
49	Vernal pool in road, recontour.			√
50	Vernal pool in road, recontour. *Revised mapping by RECON.			√
51	Weed within the vernal pool.			
52	Weed within the vernal pool.			
53	*Unable to relocate vernal pool.			
54	*Unable to relocate vernal pool.			
55	Weeding.			
56	*Unable to relocate vernal pool.			
57	Vernal pool in road, recontour. *Revised mapping by RECON.			√
58	Vernal pool in road, recontour. *Revised mapping by RECON. Trim shrubs east side of pool.			√
59	Vernal pool in road, recontour. *Revised mapping by RECON. Trim shrubs west side of pool.			√
60	No restoration.			
61	Recontour. *Revised mapping by RECON.			√
62	Close trail. *Revised mapping by RECON.			√
63	Vernal pool in trail. *Revised mapping by RECON.			
64	Seep. *Revised mapping by RECON.			
65	Seep. *Revised mapping by RECON.			
66	Vernal pool in road, recontour. *Revised mapping by RECON.			√
67	Bulldozed. No longer intact.			
68	Recontour. *Revised mapping by RECON.			√
68A	Recontour. *Revised mapping by RECON.			√
68B	Recontour. *Revised mapping by RECON.			√
69	Recontour. *Revised mapping by RECON.		√	
70	Weed pool.			
71	Close trail. Recontour and weed.			√
72	Close trail. Recontour and weed.			√

TABLE 8-3
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE CARMEL MOUNTAIN PRESERVE
(continued)

Vernal Pool Number	Problems/Comments/Recommendations	Sensitive Species Present	Hand Tools	Heavy Equipment
73	Close trail. Recontour and weed.			√
74	Recontour and weed, tire tracks present.		√	
75	Recontour and weed, tire tracks present. *Revised mapping by RECON.		√	
76	Recontour. *Revised mapping by RECON.			√
76A	Recontour. *Revised mapping by RECON.	*Branchinecta*		√
77	Recontour. *Revised mapping by RECON.	*Branchinecta*		√
78	Recontour and weed. *Mapped by RECON.		√	
79	Recontour and weed, tire ruts present. *Mapped by RECON.		√	
80	Recontour and weed. *Mapped by RECON.		√	
81	Recontour and weed. *Mapped by RECON.		√	
82	Recontour and weed. *Mapped by RECON.		√	
83	Seep. *Mapped by Helix Environmental Inc.			
84	Not relocated. *Mapped by Helix Environmental Inc.			
85	Not relocated. *Mapped by Helix Environmental Inc. Revised by RECON, smaller pools combined into one.			
86	Not relocated. *Mapped by Helix Environmental Inc.			
87	Not relocated. *Mapped by Helix Environmental Inc.			
88	Not relocated. *Mapped by Helix Environmental Inc.			
89	Not relocated. *Mapped by Helix Environmental Inc. Revised by RECON, smaller pools combined into one.			
90	Not relocated. *Mapped by Helix Environmental Inc.			
91	Not relocated. *Mapped by Helix Environmental Inc.			
92	Not relocated. *Mapped by Helix Environmental Inc. Revised by RECON, smaller pools combined into one.			

TABLE 8-3
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE CARMEL MOUNTAIN PRESERVE
(continued)

Vernal Pool Number	Problems/Comments/Recommendations	Sensitive Species Present	Hand Tools	Heavy Equipment
93	Not relocated. *Mapped by Helix Environmental Inc.			

NOTE: See Figures 8-1e through 8-1j.

*Mapped vernal pool locations have been provided by the City of San Diego, RECON, and Helix Environmental Inc. Vernal Pools that have been revised, remapped, or added by RECON have been denoted. Restoration on those vernal pools which are located on private land would occur pending land acquisition. Restoration of vernal pools located on SDG&E access roads would occur if they are no longer in use, or if other access roads can be used on the Preserve.

southern mixed chaparral and scrub oak chaparral communities. Please refer to Figures 5-2e-h for the location of vernal pool complexes on Del Mar Mesa. Table 8-4 list vernal pool indicator species present in the area. Detailed vernal pool and depression mapping for restoration purposes was prepared for pools located in existing roads. Existing vernal pools located away from roads have not previously been mapped and mapping all the pools on Del Mar Mesa was beyond the scope of this Plan.

Intact vernal and relatively undisturbed vernal pools located and mima mound topography is associated with vernal pools in portions of Del Mar mesa, but the mounds are not as readily apparent as in other portions of the County due to the dense upland vegetation particularly in the scrub oak community. Vernal pools on Del Mar mesa are known to support State and Federally listed pool species including San Diego mesa mint, San Diego button celery and spreading navarretia and another sensitive vernal pool species, little mousetail (*Myosurus minimus* var. *apus*).

Other sensitive species typically associated with vernal pools on Del Mar mesa include California adder's-tongue, Orcutt's brodiaea, and San Diego goldenstar. Sensitive animal species associated with vernal pool habitat on Del mar mesa include the two-striped garter snake, western spadefoot, and the federally endangered San Diego fairy shrimp, discussed below.

There are numerous vernal pools present on mesas within the eastern third of the Del Mar Mesa preserve and these vernal pools have a better developed vernal pool flora than the Carmel Mountain pools. Species dominating these pools are San Diego button celery, San Diego mesa mint, water starwort, stone-crop, and woolly marbles. Some of the larger and deeper pools are distinguished by spikerush (*Eleocharus* sp.). Smaller populations of California adder's tongue are present in some pools. Downingia (*Downingia cuspidata*) and little mousetail are present in the southeastern pool complex.

6. Current Status of Vernal Pools on Del Mar Mesa

Numerous vernal pools occur on Del Mar mesa in several areas (see Figures 5-2e and 5-2f). Vernal pools located away from existing roads and trails in the chaparral vegetation are the least disturbed and weedy. A portion of the vernal pools on Del Mar mesa have been damaged by road grading, off-road vehicle traffic, and creation of new trails by mountain bikes. Levels of damage to the pools ranges from pools that are undisturbed relatively to pools that have been nearly eliminated by past road grading and associated vehicle traffic. Pools that have been the most severely impacted are located in and adjacent to roads and unauthorized trails through the CDFG vernal pool preserve area and along the graded access roads west of the preserve. In some cases vernal pools along the graded roads have been bisected and formerly contiguous sections of pools are now divided by the access road.

TABLE 8-4
VERNAL POOL PLANT INDICATOR SPECIES FOR DEL MAR MESA PRESERVE

Plant Species	Type
Orcutt's brodiaea *Brodiaea orcuttii*	Annual, vernal pools and foothill springs
Water-starwort *Callitriche marginata*	Annual, vernal pools and moist openings
Chaffweed *Centunculus minimus*	Annual, vernal pool specialist in region
Stone-crop *Crassula aquatica*	Annual, vernal pools and ephemeral wetlands
Annual hairgrass *Deschampsia danthonioides*	Annual, vernal pool specialist in region
Downingia *Downingia cuspidata*	Annual, vernal pool specialist
Waterwort *Elatine brachysperma*	Annual, ephemeral wetlands, muddy shores
Elatine californica	Annual, ephemeral wetlands, muddy shores
Slender spikerush *Eleocharis acicularis* var. *acicularis*	Perennial, ephemeral wetlands
Pale spikerush *Eleocharis macrostachya*	Perennial, ephemeral wetlands
San Diego button celery *Eryngium aristulatum* var. *parishii*	Perennial, vernal pool specialist in region
Howell quillwort *Isoetes howellii*	Annual, vernal pool specialist
Orcutt quillwort *Isoetes orcuttii*	Annual, vernal pool specialist
Toad rush *Juncus bufonius*	Annual, weedy native of ephemeral wetlands
Flowering quillwort *Lilaea scilloides*	Annual, ephemeral wetlands, streams & lake edges
Grass poly *Lythrum hyssopifolia*	Annual, wet habitats
Montia fontana	Annual, vernal pool specialist in region
Little mouse tails *Myosurus minimus*	Annual, vernal pool specialist in region
Spreading navarretia *Navarretia fossalis*	Annual, vernal pool specialist in region
Hooked navarretia *Navarretia hamata*	Annual, vernal pool specialist in region
Lemon canary grass *Phalaris lemmonii*	Annual, moist areas
Pill-wort *Pilularia americana*	Perennial, ephemeral wetlands
Adobe allocarya *Plagiobothrys acanthocarpus*	Annual, shallow vernal pools and moist openings
Plantain *Plantago elongata*	Annual, vernal pools, saline and alkaline places

TABLE 8-4
VERNAL POOL PLANT INDICATOR SPECIES FOR DEL MAR MESA PRESERVE
(continued)

Plant Species	Type
Dot-seed plantain *Plantago erecta*	Annual, shallow vernal pools and moist openings
San Diego Mesa mint *Pogogyne abramsii*	Annual, vernal pool specialist
Dwarf woolly-heads *Psilocarphus brevissimus*	Annual, vernal pool specialist
Woolly-heads *Psilocarphus tenellus*	Annual, vernal pool specialist
Bladder clover *Trifolium depaupertaum* var. *amplectans*	Annual, wet meadows, open alkaline or spring-moist heavy soils

List taken from Bauder and McMillan 1996.
NOTE: Vascular plant species known to occupy natural vernal pools in the Del Mar Mesa Preserve region. Species identified as "vernal pool specialists" are found almost exclusively in natural vernal pools in the region.

a. Endangered and Threatened Vernal Pool Species on Del Mar Mesa

The restored vernal pools will be designed to support San Diego Mesa mint, San Diego button celery, spreading navarretia, and other vernal pool indicator plant species. Table 8-4 lists vernal pool indicator species for Del Mar Mesa.

San Diego Mesa Mint (*Pogogyne abramsii*)

San Diego mesa mint is a member of the Lamiaceae family. This annual herb flowers from April to June and is found only in vernal pools within San Diego County. This species is state and federally listed as endangered and is a CNPS *Inventory* (Skinner and Pavlik 1994) List 1B species. San Diego mesa mint is covered under the MSCP and is considered a narrow endemic species.

San Diego Button Celery (*Eryngium aristulatum* var. *parishii*)

San Diego button-celery is a member of the parsley family (Apiaceae). This annual/perennial herb is federally listed as endangered, state listed as endangered, and a CNPS List 1B species. San Diego button celery was designated as a federally listed endangered species on August 3, 1993 (USFWS 1993). It is also a covered species in the MSCP. San Diego button-celery is an annual/perennial species restricted in distribution to Riverside County, San Diego County, and Baja California, Mexico, where it occurs in vernal pools. *Eryngium* is one of the few perennial species found in vernal pools. While the plant can reproduce clonally, it relies largely on seed germination for successful reproduction. This species has become endangered from habitat loss and fragmentation over recent decades.

Spreading Navarretia (*Navarretia fossalis*)

Spreading navarretia is a member of the phlox family (Polemoniaceae). This annual herb is federally listed as threatened, and a CNPS List 1B species. Spreading navarretia was designated as a federally listed threatened species on October 13, 1998 (USFWS 1998). It is also a covered species in the MSCP. Spreading navarretia is restricted in distribution to Riverside County, San Diego County, and Baja California, Mexico, where it occurs in vernal pools.

San Diego Fairy Shrimp (*Branchinecta sandiegonensis*)

The San Diego fairy shrimp is federally listed as endangered and is covered by the City of San Diego's Multiple Species Conservation Program (1995). This species is restricted to vernal pools in coastal southern California and south to northwestern Baja California, Mexico (USFWS 2000). The life cycle of fairy shrimp is relatively simple, with larvae hatching out of dormant cysts after being covered with water for a prescribed period of time, developing into adults, and mating and laying eggs before the pool dries. The development time is influenced both by the water temperature and the species-specific responses to environmental cues including water chemistry. San Diego fairy shrimp are found in the spring in vernal pools and other ponded areas that are generally less than 30 centimeters deep. This species takes between 3 and 8 days to hatch and development to the adult stage takes between 7 and 20 days.

b. Proposed Vernal Pools Restoration Areas

Vernal Pool Restoration Program for Del Mar Mesa

Lands formerly supporting San Diego mesa hardpan vernal pool habitat, eliminated by topographic disturbance and the loss of

hydrologic ponding characteristics, will be restored. The vernal pools to be restored on Del Mar mesa will support vernal pool indicator species historically known to be present. Plants on the list of vernal pool indicator species for Del Mar Mesa (see Table 8-4) should be considered for reintroduction into restored vernal pools on Del Mar Mesa.

The potential to reexpand populations San Diego Mesa mint, San Diego button celery, spreading navarretia and other vernal pool indicator plant species is high. Restored pools that do not currently support the federally listed San Diego fairy shrimp (*Branchinecta sandiegonensis*) could be inoculated with shrimp cysts after reconstruction with USFWS approval.

RECON has mapped 93 vernal pools and depressions within the unauthorized road/trail on CDFG land and the SDG&E access roads to the west (Figures 8-2a-h). The pools that should have the highest priority for restoration activities are located in the CDFG preserve along the unauthorized road/trail east-west that traverses the site.

On Del Mar Mesa preserve the southeastern most road accesses the Caltrans vernal pool reserve and ends at the southeastern corner of the site. Many of the roads and trails bisect vernal pool habitat within the chaparral. Vernal pools are located alongside and in some cases within the roads throughout the preserve. Deep depressions and road ruts have been made by vehicles in these areas during the wet seasons. The southeastern unauthorized road/trail traverses the fenced off vernal pool reserve and is recommended for future formal closure. Trespass mountain bike activity and foot traffic are the primary causes of disturbance in the CDFG preserve.

The portion of SDG&E access road that heads north through the preserve bisects vernal pools habitat. Restoration of pools in and adjacent to roads that are part of the proposed trail system are of lower priority for restoration due to the necessity to maintain access routes for SDG&E and to private inholdings. Table 8-5 lists the recommended restoration tasks for the 44 mapped depressions in the east-west road that traverses the CDFG vernal pool preserve and the approximately 44 additional depressions located in existing SDG&E access roads.

Past Vernal Pool Restoration Activities at Del Mar Mesa

In 1986, 40 artificial vernal pools were created by Caltrans on Del Mar Mesa. This project was intended to mitigate for loss of San Diego mesa mint that was impacted by the construction of Highway 52. A detailed summary of the restoration activities performed as part of this Caltrans mitigation

TABLE 8-5
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE DEL MAR MESA PRESERVE

Vernal Pool Number	Problems/Comments	Sensitive Species Present	Hand Tools	Heavy Equipment
1	Close trail to pool.	*Eryngium aristulatum* var. *parishii*		
2	Minor road rut repair with hand tools.		√	
3	Smooth rough spots and trail/road rut ridges going through pool. Adjacent weedy areas.		√	
4	Enlarge pool. Remove weedy fill east of pool. Weedy area on east boundary.	*Eryngium aristulatum* var. *parishii*		√
5	Enlarge pool. Remove weedy fill east of pool.			√
6	Enlarge pool. Weed around pool.			√
7	Enlarge and recontour pool.	Immature fairy shrimp observed		√
8	Remove fencing and combine with existing adjacent pools to north/south.	Immature fairy shrimp observed		√
9	Enlarge pool. Remove road ruts and weed. Remove fencing on southside of road and connect with adjacent existing pools.	Immature fairy shrimp observed *Eryngium Aristulatum* var. *parishii*	√	√
10	Recontour and weed pool. Remove fence and connect with adjacent existing pools to south. Remove berm south of fence.	*Eryngium Aristulatum* var. *parishii*	√	√
11	Recontour and weed pool.			√
12	Enlarge and recontour pool.			√
13	Enlarge pool. Remove fence and connect with existing pool on south side.	*Eryngium aristulatum* var. *parishii*		√
14	Enlarge pool. Remove fence and connect with existing pool on south side.	*Eryngium aristulatum* var. *parishii*		√
15	Enlarge pool. Remove fence and connect with existing pool on south side.	*Eryngium aristulatum* var. *parishii*		√
16	Enlarge and recontour pool.			√
17	Enlarge and recontour pool.			√
18	Enlarge, weed, and recontour pool. Remove fence to south.	*Eryngium aristulatum* var. *parishii*		√

TABLE 8-5
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE DEL MAR MESA PRESERVE
(continued)

Vernal Pool Number	Problems/Comments	Sensitive Species Present	Hand Tools	Heavy Equipment
19	Enlarge and recontour pool.			√
20	Enlarge and recontour pool.			√
21	Enlarge and recontour pool.			√
22	Enlarge and recontour pool.			√
23	Enlarge and recontour pool.			√
24	Enlarge and recontour pool.			√
25	Enlarge and recontour pool.			√
26	Enlarge and recontour pool.			√
27	Enlarge and recontour pool.			√
28	Enlarge and recontour pool.			√
29	Enlarge and recontour pool.			√
30	Enlarge and recontour pool.			√
31	Enlarge and recontour pool.			√
32	Enlarge and recontour pool.			√
33	Enlarge and recontour pool.			√
34	Enlarge and recontour pool.			√
35	Enlarge and recontour pool			√
36	Enlarge and recontour pool.			√
37	Enlarge and recontour pool.			√
38	Enlarge and recontour pool.			√
39	Enlarge and recontour pool.			√
40	Enlarge and recontour pool.			√
41	Enlarge and recontour pool.			√
42	Enlarge and recontour pool.			√
43	Smooth out road ruts and weed pool.		√	
44	Smooth out road ruts and weed pool.		√	
45	Recontour.			√
46	Recontour.			√
47	Recontour and weed pool.			√
48	Recontour and weed pool.	*Eryingium aristulatum* var.*parishii, Pogogyne ambramsii* present on north side of pool.	√	√
49	Recontour.			√

TABLE 8-5
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE DEL MAR MESA PRESERVE
(continued)

Vernal Pool Number	Problems/Comments	Sensitive Species Present	Hand Tools	Heavy Equipment
50	Recontour.			√
51	Recontour.			√
52	Recontour.			√
53	Recontour.			√
54	Recontour.			√
55	Recontour.		√	
56	Recontour.			√
57	Recontour, pool in road.			√
58	Recontour.			√
59	Recontour; and remove berm in road, join with pool #57.			√
60	Recontour; remove berm in road, join with pool #58.			√
61	Recontour.			√
62	Recontour.			√
63	Not relocated, as mapped by City of San Diego.			
64	Recontour; join with pools #65 and #68.			√
65	Recontour; join with pools #64 and #68.			√
66	Recontour; remove road berm and join with pools #67 and #69.			√
67	Recontour; join with pools #66 and #69.			√
68	Recontour; join with pools #64 and #65.			√
69	Recontour; remove road berm and join with pools #66 and #67.			√
70	Recontour; remove road berm and join with pools #71 and #72.			√
71	Recontour; join with pools #70 and #72.			√
72	Recontour; join with pools #70 and #71.			√
73	Remove road berm; join with pool #74		√	
74	Recontour pool.			√

TABLE 8-5
POTENTIAL VERNAL POOL RESTORATION RECOMMENDATIONS
FOR THE DEL MAR MESA PRESERVE
(continued)

Vernal Pool Number	Problems/Comments	Sensitive Species Present	Hand Tools	Heavy Equipment
75	Recontour pool.			√
76	Recontour pool.			√
77	Recontour and weed pool.			√
78	Recontour.			√
79	Recontour; join with pool #80.			√
80	Recontour; join with pool #79.			√
81	Recontour; join with pool #82.			√
82	Recontour; remove road berm and join with pool #81.			√
83	Recontour; remove road berm and join with pools #84 and #85. *Currently on private land.			√
84	Recontour; remove road berm and join with pool #83 and #85. *Currently on private land.			√
85	Recontour; remove road berm and join with pools #83 and #84. *Currently on private land.			√
86	Recontour; remove road berm and join with pools #87 and #88. *Currently on private land.			√
87	Recontour; remove road berm and join with pools #86 and #88.			√
88	Recontour and weed pool and join with pools #86 and #87. *Currently on private land.			√

NOTE: See Figures 8-2a-h.

*Mapped vernal pool locations have been provided by the City of San Diego, as well as by RECON. Vernal pools that have been revised, remapped, or added by RECON have been denoted. Restoration on those vernal pools that are located on private land would occur pending land acquisition. Restoration of vernal pools located in SDG&E access roads (pools #45, #46, #56-#88) would occur if they are no longer in use, or if other access roads can be used on the Preserve.

program can be found in Black and Zedler 1998.

Management of Existing Vernal Pools on Del Mar Mesa

Long-term management of existing vernal pools not requiring restoration should focus on controlling recreational access and implementing the weeding program described later in this chapter. Pools adjacent to the graded roads west of CDFG preserve will require more intensive weeding efforts than pools located away from roads. The many undisturbed pools are currently relatively weed free and land managers will need to perform annual monitoring checks to identify and address any new weed invasion problem areas.

C. Vernal Pool Restoration Implementation Plan

1. Rationale for Expecting Implementation Success

Existing examples of vernal pool restoration projects in the San Diego region range in age from one to 20 years. In the oldest example, which was a controlled study evaluating the effects of topographic restoration and seed dispersal facilitation (Scheidlinger et al. 1985), vegetation in the restored pools and disturbed areas of the site with persisting pool hydrology was equivalent after 14 years to that of natural pools (Patterson 1995). In restoration programs conducted on Lopez Ridge (Patterson and Netting 1994a) and Naval Air Station (NAS) Miramar (Patterson and Netting 1994b) and California Terraces on Otay Mesa (RECON 1997, 2000), restoration success criteria similar to those proposed herein were met within two seasons. Other local vernal pool restoration projects in various stages of planning and implementation are being undertaken on Otay Mesa, NAS Miramar, and Camp Pendleton.

Vernal pool creation projects in California have been undertaken in many localities in the Central Valley and in Santa Barbara (Ferren and Givertz 1990). Although these projects have met with mixed success, most workers in the field agree that while self-sustaining ephemeral wetland habitat for particular target species is possible to create, this habitat should not be considered an equivalent substitute for natural habitat (Ferren and Givertz 1990). In cases where limited natural habitat is available, vernal pool recreation and restoration becomes an important method in preserving vernal pool habitat and the species that depend on it.

Restorationist Qualifications

The restoration project biologist should have a minimum of five years of vernal pool restoration experience in coastal Southern California. The project biologist should be able to demonstrate an understanding of the special growing requirements vernal pool plant species as they relate to the restoration and enhancement of vernal pools. The project biologist or biology team must have the necessary state and federal permits to work with listed vernal pools species.

2. Site Preparation

a. Preliminary Design and Engineering

Conceptual planning of the restoration area involves the creation of a preliminary design for the topographic reconstruction for each vernal pool site. The reconstruction concept plan below is based in part on the reexcavation of basins that appear to have been filled with soil due to the erosion and leveling of adjacent mounds, when present. The general locations for the proposed restoration basins have been determined and mapped in the field. Detailed final grading

plans should be prepared prior to implementation of restoration activities.
A topographic base map depicting 0.5-foot topographic contours from the existing surface should be prepared by a topographic engineering survey within the proposed vernal pool restoration sites. After reconstruction, the boundary of the restored vernal pools will be recorded in the field using post-processed GPS with a horizontal accuracy of less than one foot. The final grading plans will be replotted at 1 inch equals 40 feet, showing pool boundary, existing path and level, and finished 0.5-foot topographic contours for use in the field. Each pool boundary will be marked with contractor sand and the finished basin floor and outflow elevations will be checked with laser survey equipment.

b. Topographic Reconstruction

Vernal pools to be restored on both Carmel Mountain and Del Mar Mesa are primarily located on existing roads and trails. In general, pool basin restoration will reverse the topographic effect of disturbance on the site, consisting primarily of erosion and the filling in of the depressions. The resulting hydrologic effect of this kind of disturbance is a reduction in the capacity of the site to capture and store rainwater. The primary physical change accomplished by this project will be the removal of a portion of the fill material from the restoration areas to restore pools and possibly restore the natural hydrology of existing depressions to enhance ponding and retention of water within the preserves. On Carmel Mountain material removed from excavated basins could be salvaged and used to cover roads and trails proposed for closure where all the topsoil has been previously removed by road grading. Use of salvaged topsoil on closed roads that have been graded to the sandstone hardpan would create better conditions for plant restoration and establishment.
On Del Mar Mesa within the CDFG preserve soil removed from excavated basins can be used to reconstruct low mounds on the site, where appropriate. Some vernal pools on the site are associated with mounds, while others are not. Any excess fill material not used in mound reconstruction should be removed from the site. Existing non-natural features such as roadways and deep vehicle tracks will be regraded as appropriate to restore more natural soil conditions. Grading activities will be conducted during the fall, prior to seasonal rains, to minimize unintended compacting of the soils by grading equipment. The grading will be conducted under the direction of a qualified biologist with vernal pool restoration experience. Areas that are to remain unaffected by restoration activities will be marked prior to implementation.
Grading will be implemented using small-tracked dozers with ripping tines and slope boards, and a sheep's foot for mound construction. The grading contractor and operators will also be experienced in vernal pool restoration work. The restoration team will include a qualified surveyor to assure that the grading plan is implemented as designed.

c. Barriers

Concurrent with the implementation of the restoration grading, vehicle barriers such as wooded split rail fences will need be erected and maintained around the perimeter of the vernal pool restoration sites on Carmel Mountain (see Figures 8-1e-j). On Del Mar mesa gates and vehicle barriers are in need of repair and enforcement patrols will be needed to reduce and minimize the ongoing vandalism to fences and gates.
Steel signs attached to the fence will provide notice that the area is an ecological preserve, notify that trespassing is prohibited, and cite penalties for trespass violation including liability for repair of any damage within the barrier such as disturbance of soil or vegetation. Signage will be provided at 200-foot intervals around the entire restoration area.

3. Planting and Restoration Plan

a. Reintroduction of Vernal Pool Biota

Restoration of the native vernal pool habitats within the preserves requires the reintroduction of plants and animals at the site in addition to the physical reconstruction described above. The restoration of vernal pool habitat can be greatly accelerated by the active transport of propagules from donor sites into the restored ponds (Scheidlinger et al. 1985; RECON 1999). This will be accomplished by the redistribution of seeds, spores, bulbs, eggs, and other propagules from on-site vernal pools; as well as by the translocation of the propagules of individual species from off-site habitats.

b. Seed Collection

- Prior to the initiation of grading in the restoration site, vernal pool seed collection will be conducted both at Carmel Mountain and Del Mar Mesa Preserve. It has been experimentally demonstrated that it is best to collect seeds within five miles of the proposed restoration or enhancement site. Vernal pool indicator species listed in Table 8-2 for Carmel Mountain and Table 8-4 for Del Mar Mesa, should be considered for introduction to the created pools.

- The hand-collected vernal pool seeds would either be distributed in the basins immediately following the completion of topographic reconstruction or just prior to or after significant rain events at the discretion of the project biologist.

c. Translocation of Endangered Species

- Three listed plant species are known to currently still persist Del Mar Mesa Preserve vernal pool complex, San Diego button celery, San Diego Mesa mint and spreading navarretia. These species will be introduced into the restored pools from seed collected on site. San Diego fairy shrimp may also be introduced to restored vernal pools. As mentioned previously, San Diego fairy shrimp may be introduced into pools that do not currently support this species. Surveys determining their presence or absence will be conducted prior to this implementation.
- Less than five percent of the seed crop from San Diego button celery San Diego Mesa mint and spreading navarretia on the site would be collected while in fruit during the summer/fall. This seed will be stored in labeled bags or boxes that are adequately ventilated and kept out of direct sunlight in order to prevent the occurrence of fungus or excessively heating the seed. Seed will be distributed into restored pools that do not support existing populations of San Diego button celery, San Diego Mesa mint or spreading navarretia.

The San Diego fairy shrimp is known to currently still persist in the vernal pool complexes on the Preserves. Shrimp cysts would only be introduced into pools that do not support existing populations of San Diego fairy shrimp. The following translocation guidelines would be adhered to for any fairy shrimp translocation effort.

- Vernal pool soil would be collected when it is dry to avoid damaging or destroying fairy shrimp cysts, which are fragile when wet.
- A hand trowel or similar instrument shall be used to collect the sediment. Whenever possible, soil shall be collected in chunks. The trowel shall be used to pry up intact chunks of sediment, rather than loosening the soil by raking and shoveling which can damage the cysts.
- Soil containing fairy shrimp cysts shall not be introduced into pools that may already have populations of any species of shrimp.

d. Establishment of Vernal Pool Target Species

Necessary criteria for this restoration plan include enhancement of populations of three sensitive plant species, San Diego button celery San Diego Mesa mint and spreading navarretia in vernal pools on Del Mar Mesa. If restored pools have the hydrologic conditions suitable support San Diego fairy shrimp cysts will be introduced in the vernal pools following the guidelines listed above.

San Diego Button Celery (*Eryngium aristulatum* var. *parishii*)

All the restored vernal pools will also be suitable for introduction of San Diego button celery. The introduction of this species will add to the biodiversity of the restored pools and help offset previous impacts to the San Diego button celery populations in the area. Following topographic reconstruction, vernal pools will be inoculated with San Diego button celery. Seed for inoculation will be collected from the plants in the Del Mar Mesa Preserve.

San Diego Mesa Mint (*Pogogyne abramsii*)

The restored vernal pools will also be suitable for introduction of San Diego button celery. The introduction of this species will add to the biodiversity of the restored pools and help offset previous impacts to the San Diego mesa mint populations on Del mar mesa. Following topographic reconstruction, vernal pools will be inoculated with San Diego mesa mint. Seed for inoculation will be collected from the plants on the Del Mar Mesa Preserve.

Spreading Navarretia (*Navarretia fossalis*)

The restored vernal pools will also be suitable for introduction of spreading navarretia. The introduction of this species will add to the biodiversity of the restored pools and help offset previous impacts to the spreading navarretia populations on Del mar mesa. Following topographic reconstruction, vernal pools will be inoculated with spreading navarretia. Seed for inoculation will be collected from the plants on the Del Mar Mesa Preserve.

e. Off-Site Translocation for Species Diversity

In order to meet target species diversity criteria, translocation of plant species listed in Table 8-2 for Carmel Mountain and 8-4 for Del Mar Mesa may be implemented. All species represented in Tables 8-2 and 8-4 which are present in nearby control pools but not present on the restoration site shall be considered for introduction to the site. Species proposed for introduction to the site shall be considered to be indicative of vernal pool habitat quality and likely to have formerly occupied vernal pools on the site prior to disturbance.

4. Irrigation

No irrigation of restored vernal pools is recommended. Water inputs to the pools should be confined to natural rainfall.

5. As-Built Implementation Reporting

The first year implementation and monitoring report will include a final as-built plan. The as-built status report will include topographic mapping showing as-built topographic pool contours, basin locations, barriers, photographs of the restoration site, and a summary of project activities taken place. The status of endangered species, planting and weeding efforts, and the progress towards reaching the restoration goals will be included.

D. Maintenance During Monitoring Period

1. Maintenance Activities

Regular maintenance of the vernal pool restoration area including intensive weeding and remedial plantings will be required during the construction year and subsequent five-year monitoring period. Ongoing maintenance of the barriers and prohibition of trespassing will also be necessary. Maintenance activities will include but are not limited to the following:

- Removal of aggressive non-native weeds shall be implemented during the five-year monitoring periods for the vernal pool and adjacent upland habitats. All weeding shall be done by hand in the pool basins. In adjacent upland areas weeds can be controlled through use of approved herbicide, hand tools, or a line trimmer. The frequency and amount of weeding will depend on the rainfall patterns and other contributing factors. The preserve should be weeded at least twice a month following initial germination of non-native seedlings and should continue until all non-native species have been eliminated or restricted from setting seed.
- The monitoring biologist shall direct weeding crews to remove weeds that require control during the five-year monitoring period. The need for weeding is expected to decrease substantially by the end of the monitoring period provided successful habitat restoration has been achieved.
- All fencing and signs shall be checked and repaired as necessary once every month.
- Trash in the preserve areas shall be removed once every month, if present.
- Any persons found willfully damaging the habitat within the preserves, including but not restricted to trash dumping, off-road-vehicle activity, trespass, plant removal, and destruction of barriers, shall be prosecuted to the full extent of the law.
- After initial seeding, the site will be checked twice a week by the project biologist for the first two months, once a week for the next four months, and monthly thereafter.
- Other site problems such as vehicle damage and erosion shall be reported to the land managers with recommendations for remedial measures.

2. Schedule

Maintenance activities described above will be performed at the intervals listed in Table 8-6.

TABLE 8-6
APPROXIMATE MAINTENANCE SCHEDULE OF VERNAL POOL RESTORATION AREAS ON CARMEL MOUNTAIN AND DEL MAR MESA PRESERVES

Type/Task	Construction Year	Year 1	Year 2	Year 3	Year 4	Year 5
Site protection	Monthly	Monthly	Quarterly	Quarterly	Quarterly	Quarterly
Weed control	As-needed	As-needed	As-needed	Quarterly	Quarterly	Twice a year
Trash removal	Monthly	Monthly	Quarterly	Quarterly	Quarterly	Quarterly
Replanting/ seeding	Winter	Winter	Winter	Winter	Winter	Winter

E. Monitoring Plan

1. Monitoring Methods

a. Hydrology

Hydrological characteristics of the restoration site to be monitored include assessment of the depth, periodicity, and duration of inundation in the created, restored, and control pools. Precipitation is recorded at the nearest reporting weather station. Field methods for the hydrological monitoring are described below.

- Each restored pool shall be topographically mapped at 0.5-foot contour intervals.
- Each monitored pool will be measured for water depth every two weeks until the standing water is gone. Water depth will be measured using a ruler placed in the low point of the pool.
- A water-depth versus time chart shall be prepared for each monitored pool illustrating water depth and ponding periodicity over the basin low-point.

b. Biota

Biological parameters of the mitigation site to be monitored include species presence and relative cover (for plants) within each created and control basin. For target and indicator species, a qualitative assessment of reproductive success will be made. Photodocumentation will provide a basinwide overview of the vegetative community.

- Biological observations shall be made by a field biologist trained in the methods described below and familiar with the plant taxa listed in Tables 8-2 and 8-4.
- During the aquatic phase of each monitored basin, all plant and animal taxa observed shall be recorded.
- During the aquatic phase, each monitored basin shall be dip-net sampled for aquatic invertebrates using pole-mounted dip-nets in appropriate mesh size to capture cladocerans, ostracods, branchiopods, and tadpoles at two-week intervals until there is no ponded water or the two listed shrimp species are detected, whichever comes first.
- Each monitored basin shall be sampled for plant species presence and estimated cover using a meander survey of at least a 15-minute duration per basin within 45 days of the disappearance of standing water.
- Each monitored basin shall be photographed from an established photo point during the vegetation sampling period.

2. Vernal Pool Performance Criteria

Intermediate yearly performance criteria demonstrating progress towards the final criteria are difficult to quantify due to the unpredictability of seasonal precipitation patterns and the sensitivity of recovering vernal pool and ephemeral wetland communities to that variability. Therefore, the yearly target criteria are semi-quantitative.

- Each of the specified success criteria will be evaluated following the completion of seasonal field monitoring to determine if the final success criteria have been met and to assess the likelihood that the criteria will ever be met (taking into account the seasonal conditions).
- The final assessment of success will be based on the combined performance over the monitoring period and an analysis of the trends established.

a. Location of Control Habitat

For the Carmel Mountain restoration program a minimum 10 control pools shall be chosen from the least disturbed pools on Carmel Mountain as determined by the project biologist(s). For the Del Mar mesa restoration program a minimum of 10

control pools shall be chosen from the least disturbed pools on Del Mar Mesa. Control pools shall be chosen to include the ranges of both physical and biotic characteristics included in the long-term mitigation goals. All control pools shall support vernal pool vegetation, as defined below in the target vegetation and cover criteria.

b. Target Vegetation and Cover

- For each pool, the area of vernal pool vegetation shall be defined for purposes of this section as coincident with the area supporting a combined relative pool species cover of more than 50 percent, measured within 45 days of the disappearance of standing water. In a drought year, this criterion shall be considered to be met if the total relative cover by pool species equals that of the averaged value of control pools having similar hydrological characteristics in that year and if the qualifying area has met this criterion in a previous monitoring year.
- For each pool, the total absolute vegetative cover in areas of qualified vernal pool vegetation, not including target weed species, shall equal or exceed 50 percent of the averaged value of control pools having similar hydrological characteristics.

c. Target Plant Species Diversity

- Created basins shall support reproducing populations of a minimum number of vernal pool species equivalent to that supported by the control pools. Equivalence is met if (1) the pool species richness value for each basin (see Monitoring Plan section, below) is equal to or greater than the minimum value found in the control pools and (2) the value of pool species richness in the combined restored pools is equal to or greater than that of the control pools.

d. Target Indicator Wildlife and Endangered Shrimp Species

Characteristic animal species of vernal pools in the Carmel Mountain and Del Mar Mesa Preserve are primarily aquatic invertebrates and amphibians, although terrestrial invertebrate (especially insect) and vertebrate species are important components of the vernal pool community (Zedler 1987). Of the aquatic invertebrates, species of branchiopods, which includes fairy shrimp (Anostraca), clam shrimp (Conchostraca), and tadpole shrimp (Notostraca), are among the most distinctive inhabitants of ephemeral aquatic habitat (Pennak 1989). Unlike most aquatic invertebrates, these species are found almost exclusively in ephemeral freshwater habitats.

A number of branchiopods that are thought to occur almost exclusively in natural vernal pools have been listed or proposed for listing as endangered by the U.S. Fish and Wildlife Service, the San Diego fairy shrimp which are found in the Del Mar mesa vernal pools.

The seed shrimp (subclass Ostracoda) is another small crustacean group that is highly distinctive in vernal pools. In the United States, freshwater seed shrimp have been comprehensively studied only in the several eastern and midwestern states and in Washington (Pennak 1989). Vernal pools in the region invariably support one or more seed shrimp species, some of which may be undescribed endemic taxa (Zedler 1989).

The target indicator wildlife species listed in Table 8-7 includes species that are found primarily in natural vernal pools within the region and are therefore considered indicators of habitat quality and restoration success.

TABLE 8-7
TARGET INDICATOR WILDLIFE SPECIES FOR

CARMEL MOUNTAIN AND DEL MAR MESA

Group	Species
Anostraca	*Branchinecta sandiegonensis* (San Diego fairy shrimp)
Conchostraca	*Cyzicus* sp. (clam shrimp)
Ostracoda	*Bradleycypris* sp., *Eucypris* sp., *Heterocypris* sp., *Lymnocythere* sp., *Pseudoilycypris* sp. (seed shrimp)
Dytiscidae	*Agabus* sp. (predaceous water beetles)
Pelobatidae	*Scaphiopus hammondii* (western spadefoot toad)

- Each of the created vernal pools within the restoration area shall support populations of at least two of the species listed in Tables 8-2 and 8-4 (vernal pool indicator species).
- A plant life indicator species richness value shall be determined for each created and control pool and the richness value of created pools shall be equal to or greater than that of the control pools.

e. Target Weed Species

Non-native weed species expected to be potential significant factors in the vegetation of the vernal pools include annual grasses (*Bromus* spp.), rabbitfoot grass (*Polypogon monspeliensis*), brass buttons (*Cotula coronopifolia*), loose-strife (*Lythrum hyssopifolia*), filaree (*Erodium* spp.), sand-spurrey (*Spergularia bocconii*), curly dock (*Rumex crispus*), common knotweed (*Polygonum arenastrum*), perennial ryegrass (*Lolium perenne*), and Italian ryegrass (*Lolium multiflorum*). Of these, the *Lolium* species are some of the most significant competitors with native pool vegetation as it becomes established.

- Within the vernal pool vegetation in each restored and preserved vernal pool, the relative cover of non-native species shall not exceed one percent.
- All localities of non-native plant species within the vernal pool preserves will be eliminated as a part of ongoing maintenance activities.

3. Target Hydrological Regime

In coastal southern California, annual precipitation is highly seasonal, with most of the rainfall occurring in the winter and early spring from December through April. On the coastal mesas, summer and fall precipitation is rare and is never of sufficient magnitude to cause ponding in natural vernal pools. The first major rainfall event of the season rarely fills natural pools; this water being used to wet and recharge surface soils dried during the summer drought. Subsequent storms charge the perched water table formed in the low-permeability soil profile of natural vernal pool landscapes, which is expressed as surface ponding in basins and topographic depressions.

The formation of a perched water table and the occurrence of surface ponding requires a soil profile with very low permeability but is also highly dependent on the topography of the site. Depressions must be present as places for the ponding to be expressed and as reservoirs to capture precipitation. The shape of the perched water table surface is influenced by the pattern and capacity of basins, interbasin soil permeability, slope of the overall site, and variations in subsoil permeability such as sand lenses and holes in the hardpan. It is this surface shape, changing over time under the influence of gravity, evaporation, and precipitation, which determines the depth and duration of ponding in the depressions.

The depth and duration of water in these temporal ponds is highly dependent upon the magnitude and number of storm events, the time interval between each event, and the climactic determinants of evaporation and transpiration (temperature, humidity, sunlight, and winds) between each storm event. Annual occurrences of winter rains in the region are remarkably variable. Therefore, the success criteria for hydrological characteristics also depend on a comparison with control habitats representing the expression of long-term performance goals during each monitoring year.

a. Watershed Analysis

The restoration of mound and basin topographic relief to the mitigation site is expected to result in the restoration of natural hydrologic conditions to the sites. Currently, graded roads and vehicles have caused siltation to the extent that of the precipitation falling on the sites is unable to pond adequately to support a diverse assemblage of vernal pool species. Topographic restoration will reestablish the ability of the landscape to capture and retain precipitation.

b. Duration, Periodicity, and Depth of Inundation

- All monitored vernal pools, including the control pools and pools within the preserves, shall be monitored to record water depth over the low point in each basin during the course of six rainy seasons following restoration. From this data, a water depth–time curve shall be prepared for each basin illustrating depth and periodicity of inundation.
- Prior to the end of the monitoring period, each restored pool shall demonstrate hydrological patterns of duration, periodicity, and depth of inundation which fall within the range of variation observed in the control pools.

4. Annual Reports

Following submittal and review from City of San Diego, annual reports presenting the monitoring results shall be submitted to the USFWS. These reports shall assess both the attainment of yearly target criteria and progress toward the final success criteria. Annual reports will be submitted following each of the six project years (one construction year and five years of monitoring) for the vernal pool restoration. Annual reports shall include the following:

- A list of names, titles, and organizations of all persons who prepared the content of the annual report and participated in the monitoring activities for the year.
- Analyses of all quantitative monitoring data (success, failure, and remedial action).
- Prints or color photocopies of monitoring photographs.
- Topographic base maps identifying each monitored basin listed in the data tables.

F. Completion of Restoration

1. Notification of Completion

If the final success criteria have been met at the end of the five-year monitoring program, notification of these events shall be provided with the fifth-year report.

If the final success criteria have not been met by the end of the monitoring program, the fifth-year report will discuss the possible reasons for the failure and what should be done to bring the site to completed status. Included in the fifth-year report will be detailed plans to complete the restoration project and meet the final success criteria.

2. Agency Confirmation

Following receipt of the report the USFWS shall be permitted to visit the restoration sites to confirm completion of the restoration effort and accuracy of the jurisdictional delineation.

G. Invasive Exotic Plant Control Program

This section discusses a variety of methods involved in, and issues related to, restoration, including restoring occupied habitat; removing and controlling non-native, or non-native, plant species; preparing the site; selecting native plant species; collecting native plant seed; restoring cryptogamic crusts; using salvaged materials; monitoring and maintaining the restored habitat, and implementing adaptive management techniques.

Non-native plant removal strategies should be site-specific to take advantage of habitat breaks such as those created by large shrub patches, canyon edges, rock outcrops, or roads so that patches of weeds can be effectively controlled. Taking advantage of existing breaks will enable managers to use non-native plant removal funds most efficiently. Initially, efforts should be concentrated habitat patches that support sensitive species such as the short-leaved dudleya and vernal pools and this will improve the habitat quality in these most critical sites until resources are available to weed and restore larger areas. After non-native plant removal, populations of native species may be enhanced or re-established by hand seeding, or propagation off-site and outplanting.

The weed management program described below can be implemented over a five-year period. After weeds have been successfully controlled, a reduced level of effort will be required over the long-term to keep weeds under control. The long-term weeding program would focus on spot control of weed populations and finding and eradicating new infestations.

H. Restoring Areas Dominated by Non-native Plants when Native Species are Still Present

Native plant communities invaded by non-native species can be weeded using different methods, depending on the site conditions and the presence of sensitive resources. Some habitat patches will require only spot herbicide spraying, and possibly hand removal of individual non-native plants. Other methods can also be used, although not all non-native plant control methods may be appropriate in sensitive habitat, such as the use of pre-emergent or other herbicides.

Site-specific non-native plant control strategies will be needed. Timing of non-native plant control efforts is critical to success. If non-native plants are not killed prior to seed set, then removal effort and cost will remain high over time. Another critical component of the non-native plant removal method described below is that workers must be trained to distinguish between native and non-native plants for restoration to be successful.

This method of restoring native plant communities described below, involves removal of dead plant thatch using hand tools and "weed eaters," and return visits for spraying with glyphophosate herbicide, appears to be successful on sites in central and southern San Diego County. Thick thatch can prevent native species from germinating and or competing successfully for light and space with non-natives.

If non-native plants are present at moderate to high levels in areas that still have significant numbers of native species present, the following de-thatching technique can be used to restore or enhance these sites. De-thatching should be used in areas that have a buildup of organic matter

on the soil surface, such as annual grasses or mustard.

De-thatch and Repeat Spray/Or Hand Pull Method (in order):

- Cut thatch/dead non-native plants with "weedeaters." This can be done during the summer or early fall.
- Rake up and collect non-native plant thatch.
- Remove thatch from site and dispose of it in dumpsters, a landfill, or an area where it can be composted nearby to reduce disposal costs.
- Return to site and spray Roundup (or more selective herbicide) on non-native plant seedlings after sufficient rains have fallen in winter and spring. In sensitive plant habitat hand pulling of weeds or weed whipping will be required in the immediate vicinity of rare plants to prevent them being killed by herbicide. Hand removal should be done in a manner that minimizes disturbance to the soil surface. Careful pulling or cutting of weeds is necessary so that the control methods do not create conditions favorable for further weed invasion.
- Repeat spraying/hand pulling as necessary to prevent seed set. Other options include the use of pre-emergent herbicide prior to the first significant rain. Pre-emergent herbicides kill seeds prior to seed germination. Pre-emergent herbicides should only be used in areas that are not intended for seeding with natives.
- Repeat spraying as necessary to maintain non-native plant density to a low level. If non-native plants are controlled each season prior to flowering and setting seed, the level of effort required should decrease over the five-year period.

The non-native plant removal process must be carefully monitored because as the dominant non-native plant species are removed, other non-native plant species can multiply rapidly and replace the formerly dominant non-native species particularly in more disturbed sites.

Adaptive management strategies must quickly address control of newly dominant non-native species. Frequent site visits are necessary during the growing season to assess non-native plant removal efforts and to determine whether changes are needed in the strategy being used or the intensity of non-native plant removal efforts. This type of non-native plant removal effort requires control of weeds prior to flowering and seed development. As non-native plants are controlled over the first few years, natives will return to dominance. Removal of non-native plants by hand may be required around sensitive specie and small populations of herbaceous natives. Herbaceous annuals, which may be locally rare because of non-native plant competition, may need population augmentation and careful hand removal of non-natives to ensure expansion of native plant species.

1. Focused Weeding Areas on Carmel Mountain

Areas proposed for de-thatching and intensive weeding on Carmel Mountain are depicted in Figures 8-3a and 8-3b. Also known invasive species such as pampas grass and fennel have also been mapped. In addition to the focused weeding areas depicted in the figures, all roads and trails in the Preserve should be surveyed for weeds each spring and a control program of spot spraying, hand pulling and timely weed whipping should be implemented. Most of the Preserve is relatively weed free at this time. The greatest concentrations of weeds occur in areas formerly disturbed by grading and clearing activities. In addition areas of

recent burns should be checked frequently during the growing season to check for new weed patches and these weeds should be aggressively controlled to prevent further invasion of non-natives into burn sites. Although extensive weed invasion of most of the Preserve has yet to occur the likelihood of future weed invasions will increase with time as development surrounds the Preserve.

2. Focused Weeding Areas on Del Mar Mesa

Areas proposed for de-thatching and intensive weeding on Del Mar Mesa are depicted in Figures 8-4a-d. In addition to the focused weeding areas depicted in the figures, all roads and trails in the Preserve should be surveyed for weeds each spring and a control program of spot spraying, hand pulling and timely weed whipping should be implemented. Most of the Preserve is relatively weed free at this time. The greatest concentrations of weeds occur in areas formerly disturbed by grading and clearing activities. In addition areas of future burns on Del Mar Mesa should be checked frequently during the growing season to check for new weed patches and these weeds should be aggressively controlled to prevent further invasion of non-natives into burn sites. Although extensive weed invasion of most of the Preserve has yet to occur the likelihood of future weed invasions will increase with time as development surrounds the Preserve. There are large populations of invasive weeds including artichoke thistle

I. Seed Collection Guidelines

Seeds of native plant species used in each restoration project should be locally collected whenever possible. If a plant species was historically present in an area but can no longer be found, it should be reintroduced from the locality nearest the restoration site. It has been shown that locally adapted plants are better competitors than plants introduced from a different climate zone (Knapp and Rice 1998). Seed collection should generally occur within five miles of a proposed restoration or enhancement site. If collecting within the five mile of the site is not possible, research has demonstrated that it is best to collect seeds as close as possible within the same general climate zone. General climate zones outlined in the Sunset Western Garden Book (Sunset Publishing Corporation 1995) can be used as a guide. Reciprocal transplant experiments have shown that plants of genotypes that are not locally adapted are inferior competitors when they are moved to a different climate zone. In addition, introducing plants that are not locally adapted can be detrimental to local herbivorous insects.

Some species particularly annuals will be difficult to collect from the wild in sufficient quantity to seed the restored areas. Collecting from the wild must be limited such that it will not adversely affect source plant populations. To ensure that adequate seed is available, seed bulking (growing seed in cultivation to increase the amount of seeds) of annuals may be necessary. This seed bulking should be done at growing areas that can provide reproductive isolation from related plants from different regions. Plants from different source regions should not be allowed to hybridize at a common growing facility. Locally adapted genotypes for plants should be maintained as much as possible. It can take three years to grow native bulbs from seed to a size large enough to plant and still have high survivorship when they are planted out. Therefore, restoration of diverse grassland sites, for instance, can require several years of planting and preparation.

J. Enhancement Techniques for Native Pollinator Populations

Providing adequate habitat for pollinator assemblages is critical to the success of any restoration project. Fortunately the Carmel Mountain and Del Mar Mesa areas have significant areas where weeds have not yet invaded and these areas probably support viable populations of native pollinators. Pollinators are required to ensure that plants have high seed set and persist long term. In arid environments, many potential pollinators, including native bee species, require open ground for nesting (Buchmann and Nabhan 1996). Extensive non-native plant cover continues to invade and dominate many habitats in Southern California, resulting in a loss of open ground suitable for ground nesting pollinators. By reducing available nesting sites, the non-native plant growth is causing a decline in pollinator numbers and diversity, with negative implications for entire ecosystems. In addition to the rapid reduction in the extent of open areas required for ground nesting pollinators, competitive interactions between non-native and native plant species, are causing declines in the biological diversity of natural communities in southern California. In order to support a diverse assemblage of potential pollinators and native plant species, areas of open ground within associated native plant communities should be restored to support ground nesting bees and other invertebrates. The goal of having open ground for pollinators is compatible with rare herbaceous plant restoration efforts for the short-leaved dudleya and bulb species that tend to occur in openings within the matrix of surrounding maritime chaparral vegetation.

Restoration plantings should include nectar-producing plant species with overlapping flowering periods that extend throughout the typical Southern California growing season. Although there are exceptions, in general many of the nectar producing plants of arid Southwest environments (including chaparral, coastal sage, grasslands and vernal pools habitats in southern California) are visited by generalist pollinating insects (Buchmann and Nabhan 1996). Generalist pollinators visit more than one plant species for their nectar and pollen. To support pollinator assemblages throughout the flowering season, reestablishment and enhancement of nectar-producing plant populations should be one of the goals of restoration efforts. Generalist pollinators may require temporally overlapping nectar resources to support their populations throughout the year. At a minimum, several nectar-producing plant species should be included in restoration plantings, which in

combination flower from early spring through late summer, as seen in relatively undisturbed natural ecosystems in southern California.

For example, species which provide good nectar resources include goldfields (*Lasthenia* sp.) and tidy tips (*Layia* sp.), which flowers in early spring; gumplant (*Grindelia* sp.), which flowers later but overlaps with goldfields; and other herbs such as tarplants (*Hemizonia*) and shrubby species such as goldenbush (*Isocoma* sp.), which flower in late spring and during the summer. The re-establishment of these or other appropriate species on a restoration project site will provide a continuous nectar source to keep local pollinator assemblages supplied with resources until the fall, when many pollinating insects become dormant or enter another phase of their life cycle. Each region has its own set of nectar-producing plants, and restoration programs should be designed on a site-specific basis with the goal of supporting viable populations of potential pollinators.

K. Restoration of Cryptogamic Crusts

Although the science of restoring cryptogamic crusts is still in its infancy and the regeneration process requires a long time for full development, there are known techniques to promote conditions that are appropriate for the growth of these biotic crusts. Observations of older disturbed habitat in San Diego County and elsewhere indicate that soil crusts can recover following a disturbance. The process takes many years and proceeds more slowly in xeric environments than in more mesic sites. Biotic crust redevelopment on disturbed sites is likely to be more species diverse when intact soil crusts exist adjacent to the disturbed area. Moisture and soil conditions along with levels of disturbance are the most important factors to consider when promoting crust growth.

Belnap et al. (1999) listed these five factors which increase moisture on the soil surface and therefore promote crust development: (1) closely spaced plants; (2) flat areas (depositional surfaces rather than erosional surfaces); (3) limited surface rocks, roots, or light plant litter to slow water and wind; (4) soils with inherently high stability (silt/clay>sandy>shrink-swell clay); and (5) stable microhabitats (under shrubs, away from small drainages). As soil stability increases and human-related disturbances decrease, rich communities of cyanobacteria, mosses, and lichens become more widespread, covering all surfaces not occupied by vascular plants and rocks.

Recent attempts have been made to reintroduce soil crust organisms to restoration sites on Otay Mesa, in San Diego County. Crust organisms such as ashy spike-moss and other associated crust flora such as liverworts, mosses, fungi, and lichens have been salvaged from recently developed areas and planted into restoration sites (RECON 1999). One way to translocate soil crust organisms such as ashy spike-moss from development impact areas is to cut squares of spike-moss about the size of a greenhouse flat using hand tools and place the squares into the flats for transport or temporary storage. When soils at the restoration site are moist, the spike-moss can be planted into shallow holes excavated in the shape of the flat. The spike-moss is planted in the hole so that it is flush with or slightly below the surrounding soil surface. This placement reduces the chance that erosion will break apart the crust. New crust organisms have been grown on a small scale by placing salvaged native topsoil in greenhouse flats and then keeping them continually moist in a shaded growing structure.

These small-scale biotic crust restoration trials have produced actively growing liverworts, mosses, and ashy spike-moss. Large-scale production could be used to grow many units of crust, which can be planted at the restoration sites after non-native plants are removed or under control. Salvaged brush is also being used to promote the growth of crusts by placing branches on open ground after weeds have

been controlled. The branches alter the soil moisture conditions by reducing evaporation. Mosses and algae have been observed growing under the branches within one year after the branches have been put in place. Future efforts to promote crust development will include crust salvage from development impact sites during the summer dry season and then using the powdered dry soils to sprinkle over stable soil areas that are lightly covered with branches

L. Using Salvaged Materials

1. Topsoil

Salvaged topsoil can also be used from nearby construction sites to enhance the restoration areas, including bringing in native plant propagules and soil fauna. Opportunities for topsoil translocation include areas where existing roads or trails would be closed and the sites do not already have native plants present. The most likely location for Topsoil should only be salvaged from areas that are not infested with non-native plants. Salvaged topsoil must be placed at the recipient site as soon as possible to maintain the maximum diversity of seeds and other soil organisms. The greatest chance of success in using salvaged topsoil is to collect soil in the summer or early fall dry period. If soils are wet when moved and spread greater damage to the native seed bank and soil organisms will occur than if the soil is dry and organisms are dormant. Soil should be stockpiled only if absolutely necessary because the longer the soil is stored the greater the loss of seeds and soil fauna. If soil must be stockpiled, it should be kept dry. The depth of piles in storage should not exceed three feet to avoid composting effects, and a depth of one to two feet is preferable for maintaining seed banks. Any topsoil recipient sites should be prepared prior to topsoil delivery.

2. Brush and Rocks

The following techniques can be used to increase the structural diversity of the restoration area to provide cover sites for wildlife and to promote biotic crust redevlopment. Brush piles, scattered sticks, branches, and rock cobbles can be brought to the restoration site to increase the available cover for many animals. Brush can be obtained from nearby construction sites, either from brushed habitat impacted by development or from brush management activities adjacent to structures. Because brush material is considered a waste product and has to be chipped and removed to a landfill, most construction supervisors will truck the material to your restoration site if it is nearby the construction area. This can save the developer on costs associated with trucking the material to a landfill. Creative partnerships with developers can result in increased structural diversity of restoration sites.

Placement of decaying wood and brush in the restoration site can provide immediate cover for many animals. By bringing in brush and rocks (if appropriate to the specific site) you can "jump start" restoration by providing cover that would take many years to develop or accumulate otherwise. The use of one or two restoration enhancement techniques, such as placement of brush and rocks, can benefit multiple species when done using an integrated ecosystem approach. For example, brush piles and sticks that provide next sites for native woodrats and other wildlife can also provide food for termites that are the primary food source for orange-throated whiptails, a covered MSCP species.